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Don't forget to grow old

Memory strategies in aging

Nikita Frankenmolen

Don't forget to grow old

Memory strategies in aging

Proefschrift

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Contents

Chapter 1	General introduction	7
Chapter 2	The influence of cognitive reserve and age on the use of memory strategies	19
Chapter 3	Intelligence moderates the benefits of strategy instructions on memory performance: an adult-lifespan examination	39
Chapter 4	Memory strategy use in older adults with subjective memory complaints	59
Chapter 5	Memory strategy training in older adults with subjective memory complaints: a randomized controlled trial	69
Chapter 6	Summary and discussion	85
	References	101
	Nederlandse samenvatting	111
	Dankwoord	117
	Curriculum Vitae	119
	Publications	123
	Donders Graduate School for Cognitive Neuroscience series	128



Chapter 1

General introduction

During the recruitment of participants for the memory strategy training study one of the participants explained her mixed feelings about the label 'subjective memory complaints'. At first, she was happy that her worries about having a dementia were not confirmed and that her memory performance was in the normal range for her age. However, she still experienced memory complaints that had a negative impact on her functioning at work, at home and in social situations and she did not know how to cope with these complaints. When asked to participate in a memory training study, this participant and most of the others were highly motivated and sometimes relieved to receive a memory training.

This example vividly illustrates the effects of subjective memory complaints on everyday life. It also stresses the need for interventions to teach older adults how to cope with their complaints and improve memory functioning in daily life. In this thesis, I will first introduce the concepts of aging-related memory decline and subjective memory complaints in older adults. I will also introduce the factors that are related to these complaints. Subsequently, I will outline several memory training methods, with a focus on memory strategy training. I will elaborate on the cognitive functions underlying spontaneous strategy use and specify the factors that may moderate the effects of strategy training. Finally, I will give an outline of the studies covered in the subsequent chapters of this thesis.

Memory

Several models have been proposed in an attempt to explain how memory works. Atkinson and Shiffrin (1968) described the memory system as a Multi-Store Model of Memory (see Figure 1), including three components: Sensory memory, Short-term memory and Long-term memory. First, visual, auditory and tactile information is registered from the environment and briefly (as in ms) held in a sensory store. Through attention processes, relevant information is transferred to a short-term memory store. Here, control processes can keep this information active through rehearsal, usually for a limited amount of time (seconds to minutes at most). At this level, strategies can be used to stimulate long-term encoding or facilitate retrieval from long-term memory. The latter is considered the permanent memory store.

Although this model was initially supported by a large amount of research, it also oversimplifies the complexity of memory structure and processes (Baddeley & Hitch, 1974). The memory system is divided into two complex subsystems: short-term memory (later referred to as working memory) and long-term memory. In the model of Atkinson and Shiffrin the function of short-term memory is limited to actively maintaining information (i.e., as a rather passive store), whereas later theories have attributed a supplementary role to the *manipulation* of the same information: working memory. The multi-store model of working memory of Baddeley and Hitch (1974) is more comprehensive and accounts for

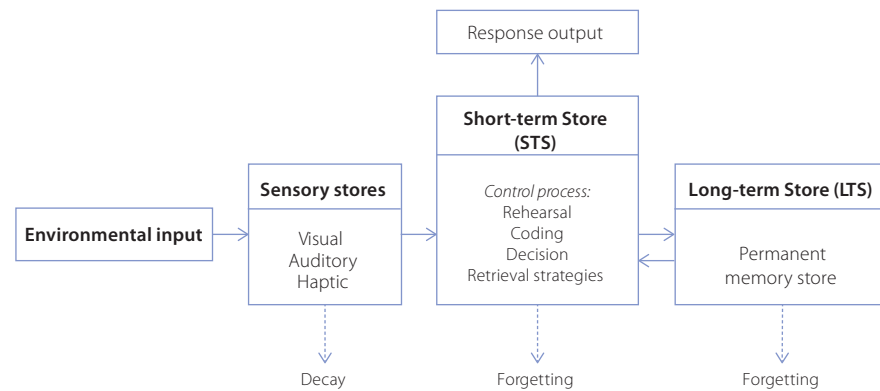


Figure 1 The Multi-Store Model of Memory (adapted from Atkinson & Shiffrin, 1968).

more observations. It consists of two slave systems and one coordinating or executive control system (Figure 2). The visuospatial sketchpad retains and stores visual-spatial information, whereas the phonological loop stores verbal / phonological input. Both have a limited capacity and can hold information for a few seconds (and roughly correspond with the Atkinson and Shiffrin's short-term store). The coordinating component is the central executive, which is defined as a subsystem that manipulates and controls attentional resources (Baddeley, 1981, 2003), and is closely related to concepts as divided attention, inhibition and selective attention. These attentional processes are important for the use of memory strategies (e.g. rehearsal, selecting important information) and enable memory formation. A more recent addition to the model is the episodic buffer, a limited-capacity store in which information is bound together into integrated representations (Baddeley, 2003, 2010). The episodic buffer may serve as an interacting system between working memory and long-term memory.

Long-term memory is the memory system in which memories are stored for longer periods of time, ranging from minutes to decades. Long-term memory can also be divided further into several subsystems (Figure 3; Squire, 2004). Non-declarative (or implicit) memory refers to automatic and 'unconscious' forms of memory and learning, and includes motor skills, priming, non-associative learning and classic conditioning. Declarative (or explicit) memory refers to knowledge of which we are aware (conscious memory). It is further divided into semantic memory (general knowledge and facts) and episodic memory (memory for personal events and their context, i.e., the "what, where and when" of memories).

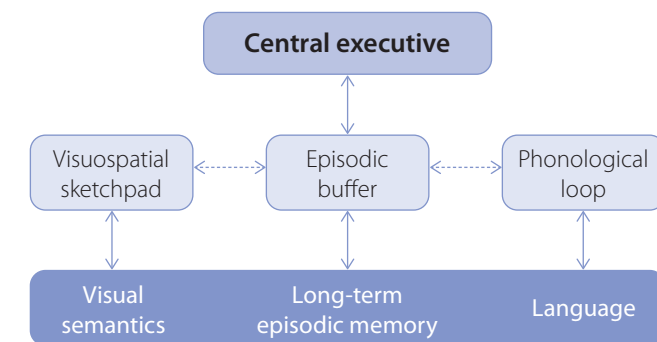


Figure 2 The working memory model by Baddeley (2010).

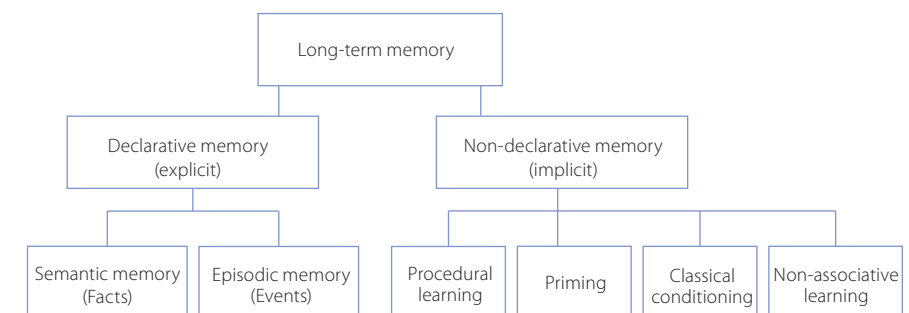


Figure 3 Long-term memory and its subsystems (adapted from Squire, 2004).

In this thesis I will focus on episodic memory, in other words on the encoding, storage and retrieval of new personal information in its context. As described above, working memory is an important system that can facilitate long-term encoding processes through the use of internal strategies.

Memory and aging

There is abundant evidence that several cognitive functions decline with aging due to age-related changes in the brain, such as the loss of grey and white matter, especially in the prefrontal, parietal and medial temporal lobes (Daselaar, Veltman, Rombouts, Raaijmakers, & Jonker, 2003; Raz et al., 1997; Sowell, Thompson, & Toga, 2004). Memory is one of the most prominent domains in which older adults experience decline in daily life. Specifically, aging is associated with a decline in episodic memory functioning (Nilsson, 2003). While non-declarative (implicit) memory and semantic memory may remain relatively intact, older adults often experience a decline in episodic memory, the memory system for personal events. In order to encode these episodic events, it is crucial to combine or integrate several units of information, among which the context of an event. For example, if someone wants to remember the name of a new person, he or she will need to remember the name in combination with the face and often the environmental and social context wherein this person was seen, referred to as associative memory. According to the Associative Deficit Hypothesis (Naveh-Benjamin, 2004; 2003; 2000), older adults are argued to be specifically impaired in associative memory (e.g., face-name associations, locations of objects, or placing events in the correct temporal order), and show less problems with remembering target information which typically consists of single items (such as memory for objects, words or scenes; Chalfonte & Johnson, 1996; Old & Naveh-Benjamin, 2008). A recent study showed that older adults not only show deficits in associative episodic memory, but that these associative deficits also extend to working memory (working-memory binding deficits; Van Geldorp et al., 2015). Working-memory binding consists of combining different features of information for a short period of time within working memory, without encoding to the long-term memory. This further supports the notion that older adults may have a general associative deficit compared to young adults, which underlies the aging-related decline in episodic and working memory.

A second hypothesis that underlies forgetting in older adults is the Interference Theory (Müller & Pilzecker, 1900). Interference occurs in learning when new information interferes with previously stored memories. When retrieving information from the long-term memory, competition arises between similar units of information. Research has shown that inhibition is the underlying mechanism that enables us to selectively retrieve the correct information, by actively decreasing the accessibility of interfering memories (Anderson, 2003). As inhibitory control decreases with aging, older adults are less efficient in suppressing competing memories (Anderson, Reinholz, Kuhl, & Mayr, 2011; Ortega, Gómez-Ariza, Román, & Bajo, 2012), resulting in memory retrieval deficits.

Another, more general explanation on cognitive aging is provided by the Processing-Speed Theory (Salthouse, 1996). This theory states that age-related differences in memory or other cognitive functions can in part be explained by an aging-related decrease in processing speed. In situations with time pressure, older adults process information too

slowly for the available limited time, resulting in a decrease in performance. Secondly, slow processing reduces the amount of information that can be held active simultaneously, resulting in deficits with higher-order dual-processing tasks. The latter is closely related to the concept of working memory (Salthouse, 1994). Several studies have indeed shown that adults need more time than younger adults to perform cognitive tasks, and that this 'mental slowness' also explains aging-related decline on other cognitive domains (for a meta-analysis see Verhaeghen & Salthouse, 1997).

Subjective memory complaints

In healthy older individuals, subjective memory complaints (SMC) are the most frequently experienced cognitive complaints in daily life. Data from the Maastricht Aging Study showed that with age these complaints about forgetfulness increase. Between age 55 and 65, 41% of the adults experienced memory complaints, whereas 52% of the adults between age 70 and 85 report memory complaints (Ponds, Commissaris & Jolles, 1997). Although a small decline in memory functioning is considered to be a normal consequence of aging, about 23% of the elderly people report subjective memory complaints which interfere with their daily life functioning (Ponds et al., 1997). A subgroup of these older adults also show objective memory impairment when assessed on a formal neuropsychological examination, which may be related to a neurodegenerative disease such as Alzheimer's disease. However, many of these older adults experience a decline in memory functioning, without any evidence for objective cognitive impairments or an underlying neurodegenerative disease or psychological disorder (Jessen et al., 2014; Jungwirth et al., 2004). Although their cognitive functioning lies within the limits of normal cognitive aging, older adults with subjective memory decline have an increased risk for future cognitive decline and dementia, ranging from 1.5 to 3-fold higher risk (Luck et al., 2015; Mendonça, Alves, & Bugalho, 2016; Mitchell, Beaumont, Ferguson, Yadegarfar, & Stubbs, 2014). Mitchell and colleagues (2014) reported that in long-term studies over 4 years, 10.9% of the older adults with subjective memory complaints converted to dementia, compared to 4.6% of those without complaints. Figure 4 shows a model from Jessen et al. (2014), in which subjective cognitive decline is seen as a preclinical stage of Alzheimer's disease with subtle decline in cognitive performance. However, other authors have shown that subjective memory complaints are unrelated to objective memory performance (Jungwirth et al., 2004; Metternich, Schmidtke, & Hüll, 2009; Riedel-Heller, Matschinger, Schork, & Angermeyer, 1999). Even though these older adults have an increased risk for cognitive decline, most of them will not develop a Mild Cognitive Impairment (MCI) or dementia (Mendonça et al., 2016), suggesting that other factors must play a role in the development of their complaints. For example, factors such as personality characteristics, a negative bias, achievement motivation, and low self-efficacy have been related to

experiencing memory complaints (Jungwirth et al., 2004; Kliegel & Zimprich, 2005; Metternich et al., 2009). Furthermore, subjective memory complaints have been found to be related to stress, depressive symptoms and a lower quality of life (Maki et al., 2014; Metternich et al., 2009; Mol et al., 2007; Montejo, Montenegro, Fernandez, & Maestu, 2011). Since these factors are amenable to intervention, this stresses the need for such interventions.

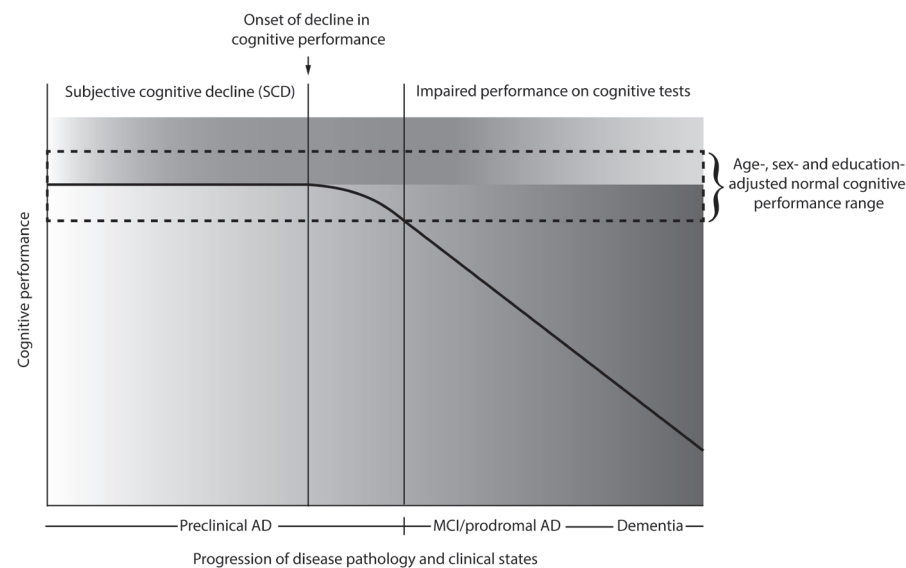


Figure 4 Model of subjective cognitive decline. Adapted from Jessen et al. (2014).

Memory training

Interventions aimed at memory complaints can be divided into two approaches. The first approach is referred to as restorative training (or brain training), which aims to improve cognitive functioning as such, especially memory functioning. Studies on the effectiveness of brain training treatments, especially working memory training, have shown promising results on memory performance, but generalization to daily life functioning remains limited (Owen et al., 2010; van Heugten, Ponds, & Kessels, 2016). Following brain training, significant improvement has typically been found on the trained tasks or near-transfer tasks (i.e., tasks that are similar to the trained task). However, only small (or even no) effects have been found on far-transfer tasks (i.e., cognitive tasks that are different from the

trained tasks) or daily life functioning (Soveri, Antfolk, Karlsson, Salo, & Laine, 2017; Vermeij, Claassen, Dautzenberg, & Kessels, 2016). Since older adults with subjective memory complaints still perform within the normal range on cognitive tasks, yet experience their complaints in daily-life situations, it could be argued that memory training should be aimed at improving memory functioning in daily-life situations, rather than improving task performance. Therefore, the present thesis focusses on the second approach: compensatory training or strategy training.

Strategy training is aimed at teaching people to compensate for memory decline by using memory aids and other or additional cognitive functions. Strategy training is commonly used in adults with memory disorders, such as adults with acquired brain damage or MCI (Cicerone et al., 2011; Reijnders, van Heugten, & van Boxtel, 2013). However, strategy training has also been shown to have positive effects in older adults with normal aging-related memory decline. Previous studies comparing memory interventions in older adults with subjective memory complaints have revealed that combining psycho-education, cognitive restructuring and strategy training is the most effective, although the majority of studies to date lack methodological quality (Gross et al., 2012; Metternich, Kosch, Kriston, Härter, & Hüll, 2010). Psychoeducation and cognitive restructuring are aimed at influencing more personal factors, such as worrying about one's memory or having dementia, and how to cope with stress. Strategy training, on the other hand, aims at giving people tools to cope with their memory complaints in daily life situations and increase their self-efficacy. Therefore, a combination of both is recommended (Metternich et al., 2010). To date, most studies have focused on measuring the effects of strategy training on objective memory performance. Therefore, further research on the effects of strategy training and its generalization to daily-life functioning is required.

Memory strategy use

Memory strategies can be divided into internal and external strategies (Dixon & Hulstsch, 1983). Internal strategies include mental encoding or retrieval strategies, such as rehearsal or visual imagery. External strategies are memory aids supporting memory function, such as the use of a calendar or taking notes. These strategies are commonly used in everyday life and are thus not specific for adults with memory complaints. However, whether older adults with subjective memory complaints use more or different strategies to compensate for their experienced memory decline is unknown. Therefore, to improve interventions including strategy training it is important to gain more insight into the mechanisms of spontaneous memory strategy use.

Several studies have demonstrated that strategy use changes with aging. Some studies suggest that aging-related decline in episodic memory, especially associative memory, can in part be explained by deficient strategy use (Shing et al., 2010). The

Production Deficiency Hypothesis, for example, states that older adults have difficulties with producing memory strategies spontaneously (Kausler, 1994). Several studies have confirmed this hypothesis, by showing that older adults more often use ineffective strategies or use fewer strategies during encoding than younger adults (Dunlosky & Hertzog, 2001; Glisky, Rubin, & Davidson, 2001; Kamp & Zimmer, 2015; Naveh-Benjamin, Brav, & Levy, 2007; Seaman, Howard, & Howard, 2015), although others have failed to support these findings (Dunlosky, Hertzog, & Powell-Moman, 2005; Shing, Werkle-Bergner, Li, & Lindenberger, 2008). A second hypothesis, the Processing Deficiency Hypothesis, states that older adults have difficulties using strategies efficiently, even when effective strategies are provided (Dunlosky & Hertzog, 1998; Hertzog, Price, & Dunlosky, 2012), which suggests that older adults benefit less from strategy training than younger adults.

Changes in strategy use in older adults can in part be explained by the aging-related decline in executive functioning (Bouazzaoui et al., 2010; Taconnat et al., 2006; Taconnat et al., 2009). The use of memory strategies relies on cognitive control processes that regulate memory functions by selecting, monitoring and organizing information during encoding in order to improve memory formation (Blumenfeld & Ranganath, 2007). Previous studies have shown that older adults use less internal strategies and relatively more external strategies than younger adults (Bouazzaoui et al., 2010; Dixon & Hultsch, 1983; Loewen, Shaw, & Craik, 1990), presumably because the use of external memory aids requires little cognitive control and can be easily used to compensate for aging-related memory decline (Lovelace & Twohig, 1990). Another important factor that might play a role in strategy use is cognitive reserve, for which intelligence, educational level, occupation and leisure activities are important contributors (Stern, 2012). Cognitive reserve reduces the risk of cognitive decline associated with aging-related brain changes by fostering the use of compensatory cognitive processes (Stern, 2002, 2009). Adults with higher levels of cognitive reserve are more likely to use other cognitive resources, such as memory strategies, to compensate for their memory decrements. For instance, Nyberg and colleagues (2003) suggest that cognitive reserve capacity may influence both production efficiency (e.g., spontaneous strategy use) and processing efficiency (e.g. efficient use of provided strategies) in older adults. However, only a few studies have examined the relationship between cognitive reserve and strategy use in older adults directly (Barulli, Rakitin, Lemaire & Stern, 2013; Tucker & Stern, 2011), which stresses the need for further examination.

Thesis outline

This thesis is aimed at further understanding memory strategy use and the effects of memory strategy training in aging. The first section of the thesis consists of two chapters and examines memory strategy use across the healthy adult-lifespan. The two chapters of the second part describe the spontaneous use of memory strategies and the effects of a memory strategy training in older adults with subjective memory complaints.

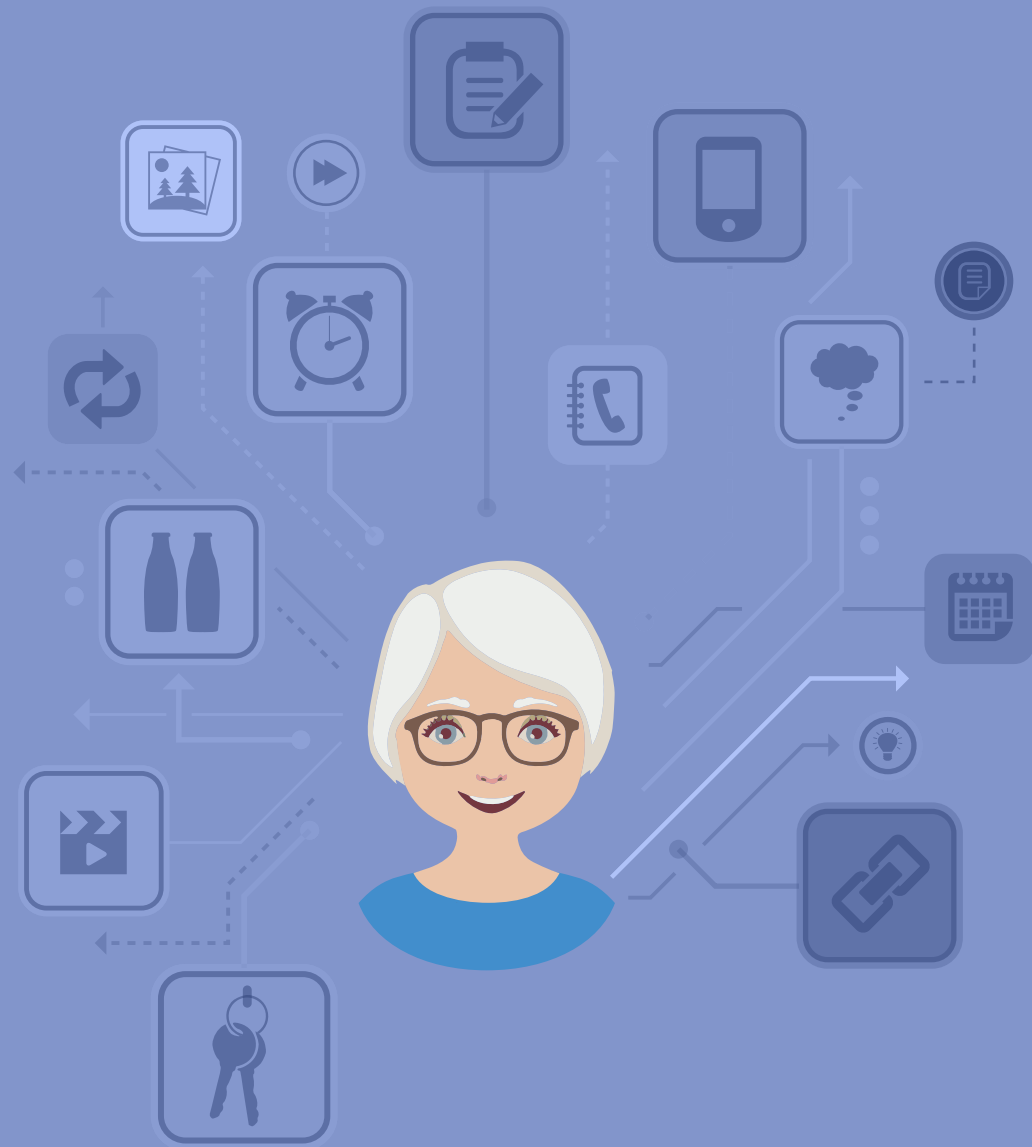
Chapter 2 examines the spontaneous use of memory strategies across the adult-lifespan, with specific emphasis on the effects of cognitive reserve, executive functioning and age on memory strategy use. Strategy use was assessed using three measures: (1) self-reported strategy use in daily life; (2) self-reported and observed strategy use in a simulated daily life situation; and (3) self-reported strategy use during a word-pair memory task.

The aim of **Chapter 3** was to investigate whether intelligence moderates the beneficial effects of strategy instructions in aging. It describes a study in which adults performed an associative memory task, either with or without receiving strategy instructions (sentence generation).

Chapter 4 focuses on the use of memory strategies in older adults with subjective memory complaints. In order to examine whether older adults with subjective memory complaints spontaneously compensate for their memory problems, self-reported and observed strategy use were assessed in older adults with and without subjective memory complaints.

Chapter 5 presents the results of the Randomized Controlled Trial (RCT). Here, we examined the effect of a memory strategy training, compared to a control memory training, in older adults with subjective memory complaints. The primary outcome measure was memory functioning in daily life, including subjective memory complaints and personal goal ratings of daily life tasks. Objective measures of memory performance and self-reported measures of strategy use were included as secondary outcome measures. In addition, predictors of treatment success were examined.

Finally, **Chapter 6** summarizes and discusses the main results of the reported studies and directions for future research are suggested. Furthermore, the clinical relevance of the conclusions is highlighted and implications for clinical practice are presented.



Chapter 2

The influence of cognitive reserve and age on the use of memory strategies

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Abstract

Background: Whether older adults use effective memory strategies to compensate for their memory decline partly depends on their executive functioning (EF). However, many studies have overlooked the role of cognitive reserve (CR). This study examines the effects of age, EF and CR on memory strategy use.

Methods: A total of 83 participants (aged 18-85 years) were included. Strategy use was assessed using three measures: (1) self-reported strategy use in daily life; (2) self-reported and observed strategy use in a simulated daily life situation; and (3) self-reported strategy use during a word-pair task.

Results: Results showed that CR was the strongest predictor of strategy use, both in daily life and during memory tasks. Although effects of age and EF were found, most of these effects disappeared when CR was added to the model. Furthermore, a higher CR was related to the use of more complex strategies and to more effective strategies in relation to task performance.

Conclusions: Higher levels of CR seem to enable individuals to use effective strategies. These results highlight the importance of the role of CR in compensating for the aging-related memory decline.

Introduction

Episodic memory is known to decline with aging, although significant individual differences have been found (Nilsson, 2003). Several studies have demonstrated that this aging-related decline can in part be explained by deficient strategy use (Shing et al., 2010). The production deficiency hypothesis, for example, states that older adults have difficulties with producing memory strategies spontaneously (Kausler, 1994). Other studies have confirmed this hypothesis, by showing that older adults more often use ineffective strategies or use fewer strategies during encoding than younger adults (Dunlosky & Hertzog, 2001; Glisky, Rubin, & Davidson, 2001; Kamp & Zimmer, 2015; Naveh-Benjamin, Brav, & Levy, 2007; Seaman, Howard, & Howard, 2015).

Spontaneous memory strategies can be divided into internal (e.g., rehearsal, visual imagery) and external (e.g., using a calendar, taking notes) strategies (Dixon & Hultsch, 1983). Older adults use relatively more external strategies than younger adults (Bouazzaoui et al., 2010; Dixon & Hultsch, 1983; Loewen, Shaw, & Craik, 1990), presumably because the use of memory aids requires little cognitive control and can be easily used to compensate for aging-related memory decline (Lovelace & Twohig, 1990). Furthermore, there is evidence that the use of internal strategies decreases with age, both in daily life (Bouazzaoui et al., 2010; Dixon & Hultsch, 1983; Loewen et al., 1990) and during laboratory memory encoding tasks (Dunlosky & Hertzog, 2001; Glisky et al., 2001; Naveh-Benjamin et al., 2007). However, other studies did not find age effects on the production of internal strategies during memory tasks (Bailey, Dunlosky, & Hertzog, 2009; Dunlosky & Hertzog, 1998; Kuhlmann & Touron, 2012; Touron, Oransky, Meier, & Hines, 2010) or in daily life (Ponds & Jolles, 1996).

The finding that older adults have particular difficulties with the use of internal memory strategies can in part be explained by the aging-related decline in executive function (Bouazzaoui et al., 2010; Taconnat et al., 2006; Taconnat et al., 2009). The use of memory strategies relies on cognitive control processes that regulate memory functions by selecting, monitoring and organizing information during encoding in order to improve memory formation (Blumenfeld & Ranganath, 2007). Previous studies have shown that executive functioning is associated with internal strategy use (Bouazzaoui et al., 2010) and that it positively influences memory performance, specifically in older adults (Bouazzaoui et al., 2014; Hinault, Lemaire, & Touron, 2016).

One crucial factor that has not been taken into account in the previously described studies on strategy use is the potential role of cognitive reserve (CR). CR is assumed to reduce the risk of cognitive decline associated with aging-related brain changes by fostering the use of compensatory cognitive processes (Stern, 2002, 2009). Adults with higher levels of CR are more likely to use other cognitive resources, such as memory strategies, to compensate for their memory decrements. Previous studies have shown that individuals with a higher CR use additional brain regions associated with better

memory task performance (Nyberg et al., 2003; Speer & Soldan, 2015; Steffener, Reuben, Rakitin, & Stern, 2011). Only a few studies have directly related CR to strategy use, showing that a higher CR is associated with more spontaneous and efficient strategy use in both younger and older adults (Barulli, Rakitin, Lemaire, & Stern, 2013; Frankenmolen et al., 2017). A limitation of previous studies on strategy use and aging is that some only included participants with high CR levels, as younger participants are university students, and older adults are matched for education (Dunlosky & Hertzog, 1998, 2001; Naveh-Benjamin et al., 2007). Other studies did not match the younger and older adults with respect to education, resulting in different CR levels between age groups or unknown CR levels, complicating the interpretation of group differences in the light of aging (Bailey et al., 2009; Kuhlmann & Touron, 2012; Seaman et al., 2015; Touron et al., 2010). Consequently, differences in CR levels may in part account for these contradicting previous results concerning strategy production deficits in older adults.

It is well-known that CR is associated with executive functioning (Roldan-Tapia, Garcia, Canovas, & Leon, 2012), suggesting an potential shared variance between executive functions and CR regarding the ability to compensate for memory decrements. Bruno, Brown, Kapucu, Marmar and Pomara (2014) for example showed that CR had a stronger effect on memory performance, way beyond the contribution of executive functions. However, to date it is unclear what the independent effects of CR and executive functioning are on memory strategy use.

Therefore, the goal of the present study was to examine spontaneous strategy use across the adult lifespan, and elucidate the precise role of age, EF and CR on strategy use. To accomplish this, we selected adults across the entire lifespan with an equal distribution of CR levels. Moreover, previous studies generally examined strategy use *either* in daily life or during task performance, and additionally did not distinguish between self-reported strategies and those that are truly employed during encoding. This latter distinction is crucial, as Saczynski, Rebok, Whitfield and Plude (2007) have shown that adults are often unaware of the strategies that they have used, suggesting they may underestimate true strategy use. To overcome these limitations, in our study we employed a strategy observation task in addition to self-report measures of strategy use in daily life and during memory tasks.

Based on previous studies, external strategy use was expected to increase with age (Bouazzaoui et al., 2010), whereas no change for internal strategy use was expected (Dunlosky & Hertzog, 2001). Additionally, the number of strategies used is expected to relate to better memory task performance (Dunlosky & Hertzog, 1998; Hill, Allen, & Gregory, 1990; Rankin, Karol, & Tuten, 1984; Richardson, 1998; Rogers, Hertzog, & Fisk, 2000). Furthermore, we expect both EF and CR to be positively related to internal strategy use, both in daily life and during memory encoding tasks (Barulli et al., 2013; Bouazzaoui et al., 2010), although we expect the effects of CR to be stronger than the effects of EF (Bruno et al., 2014; Giogkaraki, Michaelides, & Constantinidou, 2013). Finally, previous studies have

suggested that strategies that require a deeper level of processing (e.g., imagery and sentence generation) are more effective for task performance than strategies as rehearsal or associating an item to one's own environment (Dunlosky & Hertzog, 1998; Hill et al., 1990). We will therefore examine whether the use of these deeper processed strategies, which require more cognitive control, are positively related to EF and CR and negatively to age.

In summary, the present study was intended to examine: (1) the effect of age, EF and CR on the number of strategies used, (2) the effect of age, EF and CR on the use of specific strategies, and (3) the relation between strategy use and task performance.

Methods

Participants

A total of 83 participants were included in this study. All participants were residents of the Netherlands, lived independently in the community and were fluent in Dutch. Participants were recruited through advertisement and were screened over the telephone for exclusion criteria: severe psychiatric problems, neurological disorders, substance abuse, and the use of psychoactive medication. Additionally, participants were asked whether they had subjective memory complaints (e.g., whether they experienced that their memory was significantly worse than their peers, or whether they had considered seeking professional help for their memory complaints). Those with subjective memory complaints were not further included in this study. All participants voluntarily participated in this study.

Care was taken to include participants across the total adult lifespan, with an equal distribution of educational level and sex. The age distribution is shown in Figure 1. The mean age of the participants was 47.9 years (range = 18 – 85; SD = 18.0), from whom 40 were men and 43 women. Education level was rated according to the International Standard Classification of Education (ISCED-2011; UNESCO Institute for Statistics, 2012). This classification system has a range from 1 (primary school) to 8 (doctoral degree). Within our study sample the median education level of the participants was 3 (range = 1 – 7). IQ was estimated using the Dutch version (Schmand, Lindeboom, & van Harskamp, 1992) of the National Adult Reading Test (NART; Nelson, 1982). The mean IQ estimation was 103.5 (SD = 17.1). To examine the equal distribution of these demographical variables across the adult lifespan, Spearman correlations were computed. No significant correlations were found between age and sex ($r = -.07, p = .513$), education level ($r = -.18, p = .100$), or IQ estimate ($r = .16, p = .150$). Sex was also not significantly related to education level ($r = -.09, p = .438$), or IQ estimate ($r = .04, p = .730$). These non-significant correlations support the equal distribution of these demographical variables. As expected, educational level was strongly related to IQ estimation ($r = .58, p < .001$).

Both IQ estimation and education level were used as proxy for cognitive reserve (Barulli et al., 2013; Giogkarakaki et al., 2013; Sakamoto et al., 2013). First, scores were transformed into Z-scores. Z-scores reflect the standardized difference of an individual's performance level compared to the study sample's mean. These scores are computed by calculating the difference between an individual score and the mean score of the entire study sample, and dividing that difference by the standard deviation of the entire study sample. The resulting Z-score, indicates how many standard deviations a single participant's score deviates from the sample mean. Subsequently, the education and IQ Z-scores were unified into a single CR score by calculating the average of these Z-scores.

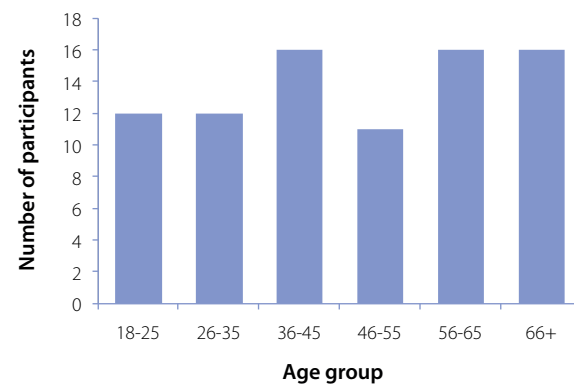


Figure 1 The age distribution of the study population.

Measures

Executive function (EF)

The selected measures of executive function were three widely used neuropsychological tests. The Trail Making Test (TMT) is a standardized executive test (Lezak, Howieson, Bigler, & Tranel, 2012). The TMT-A involves the drawing of a line between numbers from 1 to 25 and is assumed to measure visual control and mental speed. The TMT-B involves drawing a line between numbers and letters. Participants are instructed to alternate numbers and letters in a sequence, that is, 1-A-2-B-3-C, continuing to L-13. The TMT-B measures cognitive flexibility and cognitive control, when compared to TMT-A. The time to complete each part of the TMT is recorded. The TMT B/A ratio is used as an executive measure (Oosterman et al., 2010). Furthermore, a verbal fluency test was used, as speeded word generation is also considered to measure executive function (Lezak et al., 2012). In this study, the DAT letter fluency test was used (Schmand, Groenink, & Van den Dungen, 2008). Participants were instructed to produce as many words starting with a specific letter as possible within

a minute, using the letters, D, A and T. The total number of words were calculated and used as performance score. The third measure was a working memory test: the Digit Span subtest from the Dutch version of the Wechsler Adult Intelligence Scale - Fourth Edition (WAIS-IV; Wechsler, 2008). The Digit Span subtest is a widely-used, validated working memory test and consists of a forward, backward and sequencing part. The total subtest score was used. The raw scores of each subtest were used as an executive measure. For the TMT B/A ratio a higher score indicates worse performance, therefore the TMT B/A ratio score was multiplied by -1, to adjust the direction of this score. Higher scores thus represent better performance on all tests.

The three executive measures were not combined into a factor score, as it is known that various executive tests measure different aspects of executive functioning and correlate weakly among each other (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Accordingly, in the present study only a small significant correlation was found between Digit Span and Letter Fluency ($r = 0.25$). However, when controlled for age this correlation was non-significant ($r = 0.16$). No significant correlations were found between Digit Span and TMT B/A ratio ($r = 0.20$) or between Letter Fluency and TMT B/A ratio ($r = 0.03$).

Self-reported strategy use in daily life – Metamemory in Adulthood questionnaire (MIA)

The Metamemory in Adulthood questionnaire (MIA; Dixon, Hultsch, & Hertzog, 1988) describes memory functioning and knowledge about memory processes. The MIA consists of seven subscales: Task, Capacity, Change, Anxiety, Achievement, Locus and Strategy. The Strategy subscale is divided into External Strategies and Internal Strategies. The subscale External Strategies includes memory aids, such as making a shopping list or using a calendar. The subscale Internal Strategies consists of internal mnemonics, such as visual imagery, forming associations or mental rehearsal. In this study, we used the Strategy subscale of the abridged Dutch version of the MIA (Ponds & Jolles, 1996). Both Strategy subscales were found to have a reliable internal consistency, with a Cronbach's alpha of .77 for External Strategies and .84 for Internal Strategies (Ponds & Jolles, 1996). Participants report how often they use a certain strategy by rating items on a 5-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always). Each strategy subscale has 8 items, resulting in a maximum score of 40 per subscale. A total score for each subscale was calculated per participant.

Strategy use in a simulated daily life situation – Strategy Observation Task (SOT)

The Strategy Observation Task (SOT) was developed in order to observe strategy use during a memory task that mimics daily life situations. Participants were instructed to remember a story that was played as an audio clip, in order to standardize the task as much as possible. Story C of the Dutch version of the Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn, & Baddeley, 1985) was used for this purpose. This story consisted of 21 elements. Additionally, participants were asked to spontaneously recall the story

exactly 5 minutes after the end of the audio clip. In the meantime they were instructed to solve basic math problems. The instructions emphasized that participants should remember as much information as possible and that they were allowed to do or use anything to help them remember the information. A pen, paper and an alarm clock were available within reaching distance. During the instruction music was playing in the background. The volume of this music was pre-set at a level at which it was clearly distracting, but making sure that all instructions could still be understood. When asked, or at the start of the audio clip, the music was turned off. Strategic behaviour of the participants was recorded on an observation list. Examples of possible strategies were asking questions about instructions, asking to turn off the music, taking notes or setting an alarm. The total number of observed strategies was calculated for each participant.

The recall of the story ideally took place five minutes after the end of the audio clip. When participants did not recall the story spontaneously seven minutes after the end of the audio clip, they received a hint. Story recall was scored according to the scoring procedure of the RBMT. The story consisted of 21 elements. The total number of correctly recalled elements was used as the SOT recall score.

Since most internal strategies cannot be observed, a short self-report questionnaire was added to the task. After finishing the recall of the story, participants were asked which strategies they had used during this task. Subsequently, they were given a list with possible memory strategies that one could use to remember the content of a story. This strategy questionnaire used response options from the story paradigm of Saczynski et al. (2007). Examples of strategies are repetition, visual imagery or relating story to one's own life. Participants were allowed to check as many strategies as they had used and were also given the opportunity to add a strategy that was not on the list. In the scoring procedure, the open answers were compared to the multiple choice answers. In case that someone mentioned the use of a strategy in the open answer, but did not report this strategy in the multiple choice answer, this strategy was added to the multiple choice answers as 'other'. The total number of self-reported strategies was calculated for each participant and added to the total number of observed strategies. For analyses, the total number of strategies on the SOT was used, including both observed and self-reported strategies. To examine the utility of the observation scale, additional analyses were performed with the number of observed strategies only.

Task specific self-reported strategy use – Verbal Paired Associates (VPA)

In addition to strategy use in daily life and a strategy task representing daily life situations, we also included a traditional memory task. Word-pair tasks are often used to examine spontaneous internal strategy use in laboratory settings (Dunlosky & Hertzog, 1998, 2001; Kuhlmann & Touron, 2012; Naveh-Benjamin et al., 2007). In this study the subtest Verbal Paired Associates (VPA I and II) from the Dutch version of the Wechsler Memory Scale - Fourth Edition (WMS-IV; Wechsler, 2009) was used. For VPA I participants were instructed

to remember a list of 14 word pairs. Subsequently, the first word of each pair was read out loud and participants were asked to recall the corresponding word. This list was repeated four times, each time in a different order. After VPA I we administered a short questionnaire to examine self-reported strategy use. First, participants were openly asked which strategies they had used during the encoding of the word pairs. Subsequently, they were given a list with possible memory strategies that one could use to remember the word pairs and were asked to place a check mark next to each strategy that they had used. This strategy questionnaire used response options from the word-pair paradigm of Dunlosky & Hertzog (1998, 2001) and from the word-list paradigm of Saczynski et al. (2007). Examples of strategies are visual imagery, rehearsal of word pairs, creating a story or focussing on specific letters. Participants were allowed to check as many strategies as they had used and were also given the opportunity to add a strategy that was not on the list. In the scoring procedure, the open answers were compared to the multiple choice answers. In case that someone mentioned the use of a strategy in the open answer, but did not report this strategy in the multiple choice answer, this strategy was added to the multiple choice answers as 'other'. The total number of self-reported strategies was calculated for each participant.

Approximately 20 minutes after the encoding phase, participants performed VPA II, the recall phase of the task. Similar to the encoding phase, the first word of each word pair was read out loud and participants were asked to recall the corresponding word. The VPA I score consisted of the total correct encoded words, with a maximum of 56. The VPA II score consisted of the total number of correct recalled words, with a maximum of 14.

Procedure

This study was approved by the Ethics Committee Faculty of Social Sciences (ECSS) at the Radboud University in Nijmegen. Following recruitment, each participant underwent an initial telephone screening to check for exclusion criteria. When participants were eligible for inclusion in the study a test session was planned. Participants were tested individually at home in a quiet room. Telephones were turned off and no other people were present during the test session. Participants received information about the study at the beginning of the test session, signed an informed consent form and were asked for demographical information. As we aimed to examine spontaneous strategy use, participants were told that the goal of the study was to examine memory processes across the adult life span, without explicitly mentioning strategy use. After the session participants were debriefed. Each test session had a duration of approximately 50 minutes.

Statistical Analyses

For the statistical analyses IBM SPSS 21.0 was used. Alpha was set at 0.05 for all analyses. Basic assumptions were checked and outliers with a score of > 3 SD were removed. Based on these explorative analyses, the TMT B/A ratio scores of three participants were removed.

First, common assumptions (i.e., the correlations between age, CR and EF measures and their influence on memory performance scores) were checked using Pearson correlation coefficients and linear regression analyses. Second, the effects of age, CR and EF measures on the total number of used strategies were examined using Pearson correlation coefficients. Explorative analyses showed that sex was positively correlated with MIA external strategies. Therefore, partial correlation analyses were performed on this strategy measure to control for sex. To determine which variables were reliable, unique predictors of strategy use, additional linear regression analyses were performed with age, CR and EF measures as predictors and the various measures of strategy use as dependent variables. Furthermore, Pearson correlation coefficients were calculated to examine whether the use of specific strategies correlated with age, CR and EF measures. For these analyses, specific strategies were dummy-coded, with a score of 0 representing the absence of use of a specific strategy, and a score of 1 indicating that the specific strategy was used. When multiple variables correlated significantly with a strategy, additional logistic regression analyses were performed with age, CR and/or EF measures as predictors and the use of specific memory strategies as dependent variables, to determine which variables were reliable predictors of strategy use. The forward stepwise method was used. Finally, the number of strategies used was related to memory performance using Pearson correlation analyses. To examine which specific strategies were most effective in improving task performance, logistic regression analyses were performed, using the forward stepwise method. Standardized beta weights are reported for all regression analyses.

Results

Common assumptions (i.e., the correlations between age, CR and EF measures) are shown in Figure 2. Within the EF measures, only age was negatively related to Digit Span measure. CR was positively related to all EF measures. Age and CR were unrelated. The effects of age, CR and EF measures on memory performance are shown in Table 1. Age was negatively related to all memory scores. In other words, with increasing age, memory performance declined. Furthermore, CR was a positive predictor for the SOT recall score, but not for the VPA scores. Within the EF measures, only Digit Span was positively related to the SOT recall score. EF measures did not predict the VPA scores.

The effects of age, EF and CR on the number of strategies used

Table 2 shows the effects of age, EF and CR on the numbers of strategies used. The self-reported strategy use in daily life (MIA) was not significantly correlated with EF measures or age. Moderate positive correlations (cf. Cohen, 1992) were present between CR and internal and external strategy use, indicating that participants with a higher CR use more strategies in daily life.

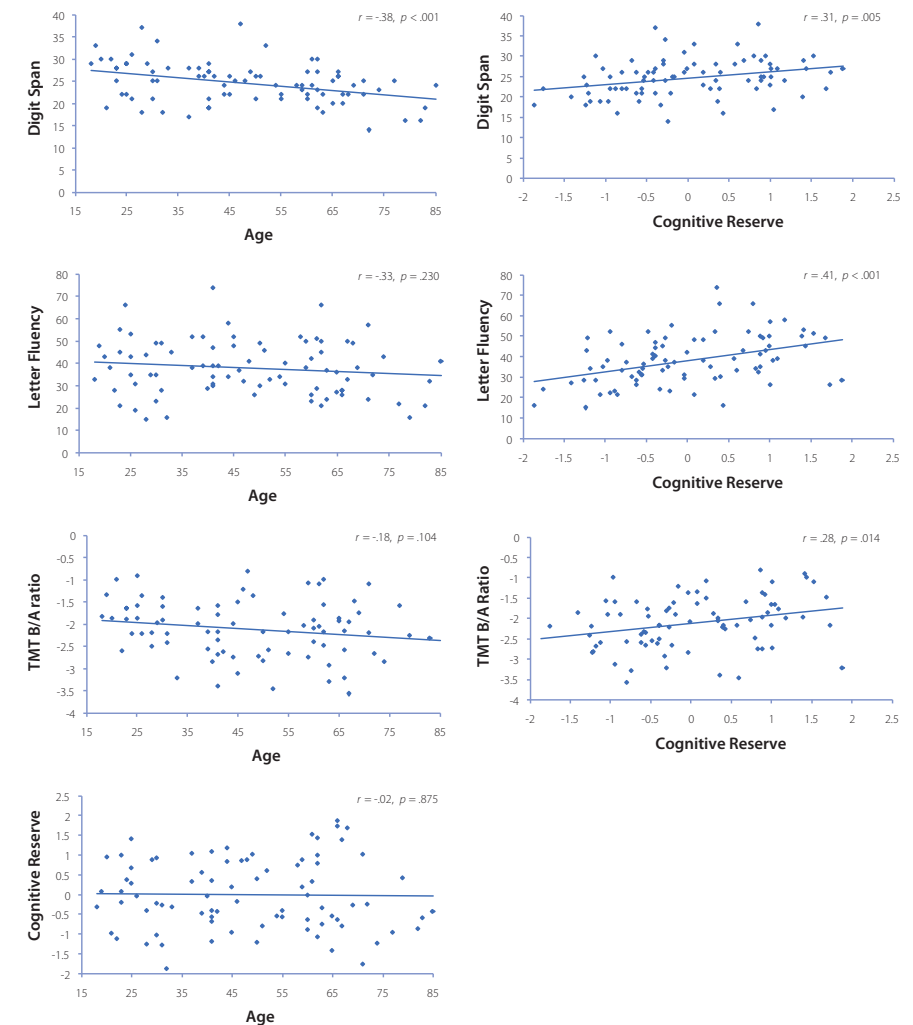


Figure 2 Plots of correlations (Pearson) between age, cognitive reserve (CR) and the three executive function measures: Digit Span, Letter Fluency and Trail Making Test B / A ratio (TMT B/A ratio)

Table 1 Effects of Age, Cognitive Reserve (CR) and Executive Function (EF) measures on memory performance.

Predictors	Performance scores		
	SOT recall β	VPA I β	VPA II β
Age	-.20*	-.41***	-.31**
CR	.47***	.11	.10
EF			
Digit Span	.29**	.12	.19
Letter Fluency	.05	.14	.17
TMT B/A	-.13	.08	-.01
	$R^2 = .44***$	$R^2 = .32***$	$R^2 = .27***$

Note. * $p < .05$; ** $p < .01$; *** $p < .001$

Trail Making Test B / A ratio (TMT B/A), Strategy Observation Task (SOT), Verbal Paired Associates (VPA).

Table 2 Pearson correlations between age, executive function (EF) measures, cognitive reserve (CR), and strategy measures.

Strategy measures	Age	CR	EF		
			Digit Span	Letter Fluency	TMT B/A
MIA internal	.01	.31**	-.11	.05	.04
MIA external	.20	.33**	-.09	.04	.01
SOT total	-.22*	.35**	.25*	-.02	.16
SOT observed	-.17	.33**	.31**	.13	.07
VPA self-report	-.20	.31**	-.03	.07	.14

Note. * $p < .05$; ** $p < .01$; *** $p < .001$

Trail Making Test B / A ratio (TMT B/A), Memory in Adulthood Questionnaire (MIA), Strategy Observation Task (SOT), Verbal Paired Associates (VPA).

With respect to the SOT, the total number of strategies was negatively correlated with age. No significant correlation was found between the observed strategies and age, indicating that the negative correlation with age was based on the self-report part of the SOT. Both SOT measures were positively correlated with CR and with the Digit Span measure of EF, with a higher CR or higher scores on the Digit Span being associated with the use of more strategies. These correlations were small to moderate. The other EF measures were not significantly correlated with the SOT.

The number of self-reported strategies during encoding of the VPA was positively correlated with CR, in which a higher CR was related to more strategy use. No significant correlations were found with EF measures or with age.

Table 3 shows the effects of age, CR and EF measures on the various measures of strategy use. When age, CR and EF measures were included in the model, only CR proved to be a reliable predictor for strategy use. Overall, a higher CR score predicted the use of more strategies on the MIA, during the SOT and the VPA. In addition, Letter Fluency was a negative predictor for the SOT total score, in which a higher score predicted the use of less strategies. No significant effects were found for age or other EF measures.

Table 3 Effects of age, Cognitive Reserve (CR) and executive function (EF) measures on strategy use.

Predictors	MIA		SOT		VPA
	Internal strategies β	External strategies β	Total strategies β	Observed Strategies β	Self-reported strategies β
Age	-.11	.11	-.18	-.13	-.19
CR	.38**	.43***	.41**	.31*	.39**
EF					
Digit Span	-.22	-.16	.08	.17	-.24
Letter Fluency	-.05	-.12	-.27*	-.10	-.03
TMT B/A	-.03	-.06	.13	-.08	.05
	$R^2 = .13$	$R^2 = .19**$	$R^2 = .21**$	$R^2 = .15*$	$R^2 = .17*$

Note. * $p < .05$; ** $p < .01$; *** $p < .001$

Trail Making Test B / A ratio (TMT B/A), Memory in Adulthood Questionnaire (MIA), Strategy Observation Task (SOT), Verbal Paired Associates (VPA).

The effects of age, EF and CR on the use of specific memory strategies

The prevalence of use of specific memory strategies during the SOT and their correlations with age, CR and EF measures are shown in Table 4. Of the observed strategies, *taking notes* was negatively correlated with age and positively with CR, Digit Span and Letter Fluency. Logistic regression analysis showed that EF measure Digit Span was the strongest predictor of the strategy *taking notes* ($OR = 1.22$, $p = .005$). The strategies *setting an alarm* and *recalling the story fluently* were positively correlated with CR and Digit Span. Logistic regression analyses showed that for *setting an alarm*, CR was the most important predictor ($OR = 2.49$, $p = .002$) and for *recalling the story fluently*, Digit Span was the most important predictor ($OR = 1.19$, $p = .014$). Of the self-reported strategies, EF measure Digit Span was negatively correlated with *relating the story to one's own life*, indicating that adults with a

Table 4 Prevalence of use of observed and self-reported memory strategies during encoding of the Strategy Observation Task (SOT) and their correlations (Pearson) with age, cognitive reserve (CR) and executive function (EF) measures.

Strategy (prevalence %)	Age	CR	EF		
			Digit Span	Letter Fluency	TMT B/A
Observed strategies					
Asked questions about instructions (84)	-.05	-.03	.01	-.16	.01
Repetition of instructions or story (69) (out loud or with lip movements)	.01	-.05	.02	-.08	-.03
Asked to turn off the music (24)	-.02	.21	.19	.18	.11
Took notes of instructions or story (74)	-.22*	.30**	.34**	.27*	-.03
Took time to concentrate or encode story (54)	-.05	.16	.03	.04	.06
Set an alarm or looked at a clock (42)	-.12	.36***	.25*	.01	.15
Recalled story fluently (77) (in a coherent way, not in keywords)	-.18	.24*	.29**	.19	-.07
Self-reported strategies					
Concentrated on story (81)	-.15	.22*	.20	-.01	.13
Repetition of story (45)	-.19	-.19	-.09	-.31*	.01
Pictured story (30)	.01	.27*	.16	.02	.30**
Related story to own life (8)	-.08	-.10	-.25*	-.15	.15
Pictured self in story (3)	.09	-.02	-.10	.02	.13
Other (15)	.04	.44***	.10	-.09	.13

Note. * $p < .05$; ** $p < .01$; *** $p < .001$
Trail Making Test B / A ratio (TMT B/A)

higher level of working memory are less likely to use this strategy than adults with a lower level of working memory. Also, *repetition of story* was negatively related to EF measure Letter Fluency. CR and TMT B/A were positively related to *picturing the story*. Logistic regression analyses showed that for *picturing the story*, EF measure TMT B/A was the most important predictor ($OR = 3.06, p = .014$). Furthermore, CR was positively correlated with *concentrating on the story* and with *other*. Adults with higher levels of CR used these strategies more often than adults with lower levels of CR.

The prevalence of use of specific memory strategies during the VPA word-pair task and their correlations with age, CR and EF measures are shown in Table 5. Age correlated negatively with *repetition of items*, indicating that older adults use this strategy less often than younger adults. EF measure TMT B/A was positively correlated with '*picturing items*'. CR and Letter Fluency were positively correlated with *creating associations between the*

Table 5 Prevalence of use of self-reported memory strategies during encoding of the Verbal Paired Associates (VPA) and their correlations (Pearson) with age, cognitive reserve (CR) and executive function (EF) measures.

Strategy (prevalence %)	Age	CR	EF		
			Digit Span	Letter Fluency	TMT B/A
Concentration (90)	-.16	.20	.12	.16	.13
Repetition of items (66)	-.29**	.05	-.06	.06	.05
Pictured items (45)	-.21	.21	.03	-.03	.24*
Created associations between items (30)	.02	.32**	-.02	.25*	.07
Created a story with items (23)	-.17	.37***	.05	.16	-.03
Created a sentence with items (11)	-.18	-.02	.17	.08	-.09
Pictured self with items (18)	.04	.12	-.12	.06	-.05
Focused on specific letters of items (18)	.15	-.06	-.14	-.21	.02
Focused on sounds of items (29)	.05	-.04	-.17	-.21	.08
Other (12)	-.07	.12	.14	-.01	.08

Note. * $p < .05$; ** $p < .01$; *** $p < .001$
Trail Making Test B / A ratio (TMT B/A)

words. Logistic regression analyses showed that for *creating associations between the words*, CR was the most important predictor ($OR = 2.17, p = .006$). CR was also positively correlated with *creating a story with the words*. Adults with higher levels of CR used these strategies more often than adults with lower levels of CR.

The relation between strategy use and task performance

The total number of strategies ($r = .36, p < .001$) and the number of observed strategies ($r = .44, p < .001$) were positively correlated to the performance during the SOT recall. Using more strategies was related to a better task performance. Regarding VPA task performance, the number of self-reported strategy use was positively correlated with VPA I ($r = .29, p = .009$) and VPA II scores ($r = .29, p = .008$), showing that a larger number of strategies was related to a better task performance, both during encoding and during the recall phase of the task.

Furthermore, we examined which specific strategies were most effective for task performance. For the SOT, the following strategies predicted task performance: *taking notes* ($\beta = .40, p < .001$), *concentrating on story* ($\beta = .27, p = .002$) and *recalling the information fluently* ($\beta = .25, p = .008$) were positively related to task performance, whereas *relating the story to one's own life* ($\beta = -.20, p = .028$) was negatively related to task performance. For the VPA I, the encoding of the word pairs, *creating associations between words* ($\beta = .30, p = .006$)

and *visual imagery* ($\beta = .27, p = .013$) significantly predicted task performance. The strategies *creating associations between words* ($\beta = .32, p = .003$), *sentence generation* ($\beta = .22, p = .028$) and *visual imagery* ($\beta = .22, p = .036$) significantly predicted VPA II recall.

Discussion

This study examined the effect of age, EF and CR on memory strategy use across the adult lifespan. The present study extended previous findings through some methodological improvements, such as including participants across the adult lifespan with matched educational attainment levels, comparing the effects of EF and CR directly and including multiple strategy measures: strategy use in daily life, observed and self-reported strategy use in a simulated daily life situation, and internal strategy use during a word-pair task. The goals of this study were to examine: (1) the effect of age, EF and CR on the number of strategies used, (2) the effect of age, EF and CR on the use of specific strategies, and (3) the relation between strategy use and task performance.

First, this study showed that CR was the strongest predictor both for strategy use in daily life and for task-related strategy use. Although this study is the first to show this relationship directly, these findings are consistent with the results of Ponds and Jolles (1996), who reported that a higher education level was related to more strategy use in daily life. In contrast to previous findings (Bouazzaoui et al., 2010; Dunlosky & Hertzog, 2001; Glisky et al., 2001; Naveh-Benjamin et al., 2007), the present study only showed a weak correlation and non-significant trends between age and strategy measures. Furthermore, the contribution of EF was small and limited to observed strategy use. Taken together, these findings suggest that CR, for which educational attainment and IQ are important proxies (Stern, 2009), plays a crucial role in strategy use. Previous studies on strategy use in aging included either participants with high education levels only (Dunlosky & Hertzog, 1998, 2001; Naveh-Benjamin et al., 2007) or did not match younger and older age groups on education level, resulting in differences in or unknown CR levels between groups (Bailey et al., 2009; Bouazzaoui et al., 2010; Kuhlmann & Touron, 2012; Seaman et al., 2015; Touron et al., 2010). Therefore, it is possible that previously reported effects of age or EF are a result of variations in education level or solely are applicable to highly educated adults. Regarding EF, the present study confirmed the strong relation between the various EF measures and CR (Roldan-Tapia et al., 2012). Although we also found effects of EF on observed strategy use, these effects were mostly eliminated when CR was added to the model. This corroborates and extends previous results of studies including both CR and EF in relation to memory performance (Bruno et al., 2014; Giogkaraki et al., 2013).

Furthermore, this study examined the relation between age, EF, CR and the use of specific memory strategies. Additionally, the relationship between strategy use and

memory performance was confirmed (Dunlosky & Hertzog, 1998; Richardson, 1998; Rogers et al., 2000; Saczynski et al., 2007). With increasing age participants less often use the strategy 'taking notes', whereas the strategy 'repetition' was used more often. CR was positively related to 'setting an alarm' or 'using a clock', which are effective strategies for prospective memory tasks (Maylor, 1990), and to 'taking notes' and 'other', which mostly included focusing on specific elements of the story. Moreover, these strategies were most effective for task performance on the SOT. Furthermore, CR was positively related to visual imagery, creating associations and creating a story between words of each word pair. Despite the fact that we did not measure the complexity of the strategies directly, these findings suggest that CR may be mostly related to more complex strategies that require a deeper level of processing, such as visual imagery, creating associations or creating a story (Dunlosky & Hertzog, 1998; Hill et al., 1990). In turn, CR may not be related to strategies that do not require semantic processing, such as repetition or focusing on specific sounds or letters. In turn, many of these strategies (e.g., creating associations and visual imagery) were also important predictors for task performance. Therefore, it seems that CR is involved in the selection of effective strategies, however, it remains unclear whether CR also increases the efficacy of specific strategies. Future studies should examine the moderating role of CR on the efficacy of specific strategies on memory performance. In summary, CR seems to be related to the use of more internal and external strategies in daily life, to the application of more complex strategies and to the use of more effective strategies in memory tasks.

In addition to CR, this study also shows a positive relation between specific EF measures and strategy use. Our EF measures consisted of a working memory test, a verbal fluency test and a flexibility test. Among these measures, working memory was the most sensitive measure for strategy use, suggesting that specifically working memory skills are of the utmost importance for strategy use. Furthermore, working memory was the only EF measure negatively related to age, which is consistent with the knowledge that working memory declines with aging (Van Geldorp et al., 2015). Although this finding may indicate that working memory plays an important role in the aging-related decline in strategy use, it may also merely indicate that working memory decline best reflects the effects of aging per se. Future studies should examine whether the aging-related decline in working memory indeed plays a unique role in the previously reported deficient strategy use in older adults (Shing et al., 2010).

The present findings clearly show that CR is involved in compensatory processes across the adult lifespan (cf. Stern, 2002, 2009). Individuals with a higher level of CR are better able to cope with aging-related cognitive decline by using other cognitive resources, such as memory strategies. EEG and imaging studies have confirmed that individuals with a higher CR use additional brain regions for encoding (Nyberg et al., 2003; Speer & Soldan, 2015; Steffener et al., 2011), suggesting the use of other cognitive processes to improve task performance. In addition, higher levels of education have been associated

with increased cortical thickness, including the medial-frontal, temporal and parietal lobes (Cox et al., 2016). Moreover, previous studies have shown that a higher CR reduces the risk of developing dementia (Dekhtyar et al., 2015; Stern, 2012), possibly because individuals who use efficient compensatory mechanisms are better able to compensate for potential disease progression. Since the use of compensatory mechanisms is crucial for memory functioning in daily life, another point of interest is whether interventions can increase strategy use in older adults. The present study has shown that CR plays an important role in the spontaneous production of memory strategies, which suggests that strategy training could be most beneficial for adults with lower levels of CR, who currently use less effective strategies. However, a study of Frankenmolen and colleagues (2017) showed that specifically older adults with higher levels of intelligence benefited substantially from strategy instructions, whereas those with lower levels of intelligence did not. Both findings are consistent with the study of Nyberg et al. (2003), which suggests that CR influences both the production efficiency (e.g., spontaneous strategy use) and the processing efficiency (e.g., efficient use of provided strategies) in older adults. Whether forms of strategy training are particularly effective in older adults with a higher or lower CR should be examined in further research.

Some limitations of this study must be noted. First, it is important to use multiple measures to define CR. The concept CR is often described as a capacity that is built through cognitively demanding and stimulating experiences, such as education (Reed et al., 2010). However, other studies suggest that a degree of literacy or verbal IQ might be a better marker for CR than the number of years of education (Alexander et al., 1997; Manly, Schupf, Tang, & Stern, 2005). Therefore, some studies, including the present study, used a combination of education and (estimated) verbal IQ as proxy for CR (Barulli et al., 2013; Giogkarakis et al., 2013; Sakamoto et al., 2013). Although education level and verbal IQ are widely used, additional information on occupational attainment and engagement in cognitively stimulating leisure activities can provide a more accurate estimation of CR (Opdebeeck, Martyr, & Clare, 2016), since these measures include lifetime experiences (Stern, 2009). In future studies we recommend to use a combination of these measures to define CR. Secondly, in the present study we used mostly self-reported measures of strategy use. Therefore, we cannot rule out the possibility that participants with higher levels of CR were more aware of their strategy use, without actually using them more often. Since memory strategies are not easily quantified, most studies rely on self-report measures (Bouazzaoui et al., 2010; Dunlosky & Hertzog, 1998; Hill et al., 1990; Saczynski et al., 2007). Only a few tasks include more objective strategy measures, such as the California Verbal Learning Test, in which a word list can be grouped into semantic categories (Delis, Kramer, Kaplan, & Ober, 1987), or a visual exploration task, in which exploration patterns can be recorded through mouse movements (Brandstatt & Voss, 2014). It would be interesting to also include more objective measures of strategy use in future research. However, these objective measures are often limited to a single strategy and ignore the metacognitive component of strategy use. We made a first attempt in

developing a task (SOT) including observation of strategy use and a self-report questionnaire. Both the total strategy scale and the observed scale predicted task performance. Moreover, we confirmed that CR was not only related to self-reported strategy use, but also to the observed strategies. Although further research in validating the SOT is needed, it seems to be a valuable measure to examine strategy use in a more objective way.

To summarize, this study is the first to show that CR plays a crucial role in the spontaneous production of memory strategies across the adult lifespan. The present study demonstrated that CR is related to more strategy use in daily life and during memory tasks. Moreover, CR is related to the use of more complex and more effective strategies. Therefore, higher levels of CR seem to enable individuals to use effective strategies to compensate for aging-related memory decline. This study highlights the importance of including measures of CR when examining memory functioning in aging.



Chapter 3

Intelligence moderates the benefits of strategy instructions on memory performance: an adult-lifespan examination

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Abstract

Background: Whether older adults can compensate for their associative memory deficit by using memory strategies efficiently might depend on their general cognitive abilities. This study examined the moderating role of an IQ estimate on the beneficial effects of strategy instructions.

Methods: A total of 142 participants (aged 18-85 years) received either intentional learning or strategy ('sentence generation') instructions during encoding of word pairs.

Results: Whereas young adults with a lower IQ benefited from strategy instructions, those with a higher IQ did not, presumably because they already use strategies spontaneously. Older adults showed the opposite effect: following strategy instructions, older adults with a higher IQ showed a strong increase in memory performance (approximately achieving the level of younger adults), whereas older adults with a lower IQ did not, suggesting that they have difficulties implementing the provided strategies.

Conclusions: These results highlight the importance of the role of IQ in compensating for the aging-related memory decline.

Introduction

Older adults often report having difficulties remembering names of people they meet. They tend to recognize the name or the face independently, but find it difficult to integrate the name and the face into a cohesive representation. This is in line with the Associative Deficit Hypothesis (Naveh-Benjamin, 2000), which states that older adults are specifically impaired in associative memory, whereas they have less problems with remembering single items (Chalfonte & Johnson, 1996; Old & Naveh-Benjamin, 2008). Some studies suggest that this may in part be due to deficient strategy use in aging (for a review, see Shing et al., 2010), and that providing strategy instructions may remove major part of the aging-related deficit in associative memory (Naveh-Benjamin, Brav, & Levy, 2007). In contrast, other studies fail to support these findings (Dunlosky, Hertzog, & Powell-Moman, 2005; Shing, Werkle-Bergner, Li, & Lindenberger, 2008). We propose that these inconsistent findings are in important part due to differences in intelligence, which is crucial for efficient strategy use (Barulli, Rakitin, Lemaire, & Stern, 2013). The goal of the current study was therefore to provide an in-depth examination of the potentially moderating role of intelligence on the beneficial effects of strategy instructions on associative memory across the adult lifespan.

Of main interest to the clinical field is the extent to which compensatory strategies can be employed in order to reduce the aging-related decline in associative memory performance. The use of memory strategies (e.g., visualization, sentence generation) relies on cognitive control processes that regulate memory functions by selecting, monitoring and organizing the content during encoding in order to improve memory formation (Blumenfeld & Ranganath, 2007). These cognitive control operations decline in aging (Craig & Bialystok, 2006) and negatively influence episodic memory performance in older adults (Bouazzaoui et al., 2014). As a result, older adults use less internal memory strategies in daily life (Bouazzaoui et al., 2010) and use less efficient strategies during memory tasks than young adults (Rogers, Hertzog, & Fisk, 2000). According to the environmental support hypothesis (Craig, 1990) older adults have a deficiency in producing efficient strategies spontaneously, but are able to implement them when environmental support (e.g. concrete strategy instructions) is available (Froger, Bouazzaoui, Isingrini, & Taconnat, 2012). Therefore, previous studies have examined whether strategy instructions can facilitate compensation for the aging-related decline in associative memory performance. Naveh-Benjamin et al. (2007) found that older adults were able to fully compensate for the decline in associative memory when strategy instructions were provided during both encoding and retrieval phases of a word-pair task, whereas the same instructions had almost no effect in young adults. These findings indicate that the associative memory deficit in older adults is at least partially mediated by a lack of spontaneous strategy use, which they can compensate for when strategy instructions are provided. In contrast, Shing et al. (2008) revealed an almost equal improvement for both young and older adults after strategy instructions in a German

word-pair learning paradigm, despite the finding that young adults used more strategies spontaneously. When using a more difficult German-Malay word-pair paradigm, older adults showed less improvement than young adults after strategy instructions and practise, indicating that either the older adults had difficulties with applying the strategy efficiently or that applying a strategy was insufficient to diminish the associative deficit. A follow-up study of Fandakova, Shing and Lindenberger (2012) showed that high-performing older adults, who performed better on strategic and associative memory tasks, showed a greater improvement after practise sessions in the difficult word-pair paradigm than low-performing older adults. This is in line with previous research, where children with better short-term memory performance benefited more from strategy instructions than children with a reduced short-term memory capacity (Cariglia-Bull & Pressley, 1990). These findings suggest that individual differences play an important role in the ability to apply strategies efficiently. Hence, to date it is still unclear whether the associative deficit in older adults can be explained by deficient strategy use and which mechanisms contribute to successful strategy application.

One crucial variable that has not been considered in these previous studies is the potentially moderating role of general cognitive abilities. Previous studies in adults with mental retardation have shown that memory impairments in individuals with a low IQ can in part be explained by deficient strategy use (Belmont & Butterfield, 1977; Campione & Brown, 1978; Detterman, 1979). Moreover, also in adults with a normal intelligence, a higher IQ estimate and a higher education level contribute to efficient strategy use (Barulli et al., 2013) and enable individuals to compensate in memory tasks (Speer & Soldan, 2015). In the study of Naveh-Benjamin et al. (2007), intelligence levels were presumably high, as the younger participants were all university students, and older adults were matched for education. Therefore, it is possible that in the study of Naveh-Benjamin et al. (2007) the younger adults showed almost no beneficial effect of strategy instructions, because they already used efficient strategies spontaneously, whereas the older adults were able to profit strongly due to their high level of cognitive abilities. In contrast, the participants in the study of Shing et al. (2008) were not explicitly matched on education level or intelligence. The question therefore arises how intelligence interacts with age regarding the beneficial effect of strategy instructions on memory performance.

The goal of the present study was therefore to examine how an intelligence estimate moderates the effect of strategy instructions on associative memory across the adult lifespan. Participants received either intentional learning instructions or additional strategy instructions ('sentence generation') during encoding of a word-pair task. One of the shortcomings of previous research (Naveh-Benjamin et al., 2007; Shing et al., 2008) is the use of extreme age groups. Most studies selectively compared older adults (\pm ages >65 years) to young adults (\pm ages 18–30 years), while ignoring middle age groups. However, it is known that cognitive control shows a gradual decline from the age of 50 (De Luca et al., 2003) or even very mild decrements from the age of approximately 30 (Craik & Bialystok,

2006; Park et al., 2002), suggesting that already in these middle age groups mild declines in spontaneous strategy use can be anticipated. Furthermore, associative memory performance gradually decreases with age (Bender, Naveh-Benjamin, & Raz, 2010). The present study addresses this limitation by including participants across the entire adult lifespan (18–85 years) and examining age as a continuous variable rather than discrete age groups. Based on previous studies, we expect an associative memory deficit in older adults. Therefore, we expect a negative effect of age on associative memory, and not on item memory. Because of the aging-related decline in spontaneous strategy use, we expect older participants to show greater improvement following strategy instructions than younger adults, resulting in an interaction effect between age and strategy instructions (Naveh-Benjamin et al., 2007).

Regarding the role of intelligence, we expect that it moderates the effect of strategy instructions on memory performance in aging. At a younger age, higher levels of intelligence are likely associated with more spontaneous strategy use. Consequently, we expect that younger adults with a high IQ benefit less from external strategy instructions than younger adults with a lower IQ (Linke, Vicente-Grabovetsky, Mitchell, & Cusack, 2011). Moreover, when memory performance declines with aging, participants with a higher IQ may be able to incorporate strategies more efficiently, resulting in a larger benefit from strategy instructions than those with a lower IQ.

Finally, studies to date commonly examined the effects of strategy instructions on immediate memory only. It is clinically relevant to examine whether the beneficial effects of strategy instructions persist after a period of time. Therefore, we tested both immediately after encoding and after a 20-minute delay period. When a recognition test is used after a 20-minute delay, only small effects of age are found on the rate of forgetting (Davis, Small, Stern, Mayeux, Feldstein, & Keller, 2003; Rybarczyk, Hart, & Harkins, 1987). Therefore, we expect the associative deficit pattern and the effects of strategy use and intelligence to remain unchanged when a delay is added between the encoding and recollection phase.

To summarize, the goal of this study is to examine how strategy use supports associative memory across the adult lifespan, to test how intelligence moderates the beneficial effect of strategy-use, and examine whether these effects persist over a 20-minute delay period.

Methods

Participants

A total of 142 participants were included in the present study. Participants were residents of the Netherlands, lived independently in the community and were fluent in Dutch. They voluntarily participated in this study. Participants were recruited through (oral) advertisement. Prior to the study, participants completed a brief screening questionnaire

to check for exclusion criteria: severe psychiatric problems, neurological disorders (e.g., stroke, dementia), substance abuse and uncorrected visual deficits or hearing loss. The Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) was administered in all participants aged 50 years and older to screen for potentially severe cognitive impairment (cut-off score: 24). One participant was excluded due to a MMSE score of 22.

Care was taken to assure that participants across the total adult lifespan were included with an equal distribution of education level and sex. The mean age of the sample was 49.0 years (range = 18 – 85; SD = 20.0), with a gender distribution of 39.7% male and 60.3% female participants. Education level was rated according to the classification of the Central Office for Statistics of the Netherlands (CBS, 2011), consisting of three levels: low, average and high. This classification is based on the International Standard Classification of Education (ISCED: United Nations Educational, Scientific and Cultural Organisation Institute for Statistics UNESCO-UIS, 2011). The low level of education consists of early childhood, primary and lower secondary education, the average level consists of secondary, post-secondary non-tertiary and short cycle tertiary education, and the high level consists of bachelor, master and doctoral degrees. Within this study sample 22.0% had a low level, 33.3% had an average level and 44.7% had a high level of education. To estimate the IQ of the participants, two subtests of the Dutch Wechsler Adult Intelligent Scale – Third Edition (WAIS-III; Wechsler, 1997) were administered: Block Design (BD) and Vocabulary (V). The subtests BD and V were included because of their high independent correlations with Full Scale IQ (FSIQ) of the WAIS-III (Wechsler, 1997). Moreover, previous studies have shown that the combination of BD and V is a reliable and valid dyadic short form, which is often used to estimate Wechsler’s FSIQ (Cyr & Brooker, 1984; Ringe, Saine, Lacritz, Hynan, & Cullum, 2002). The mean IQ estimation was 109.0 (range = 73 – 155; SD = 16.6).

Correlations between all demographical variables were assessed using Spearman correlations. The correlation matrix (Table 1) confirms the equal distribution of sex, education level and IQ estimate across the adult lifespan. No significant correlations were found between age and gender, education level or IQ estimation. As one could expect, education level and IQ estimation were strongly correlated.

Table 1 Spearman correlation matrix among age, gender, education level and IQ estimation

	Age	Gender	Education level
Gender	-.15		
Education level	-.14	-.15	
IQ estimate	-.10	-.18	.66***

Note: *: $p < .05$; **: $p < .01$; ***: $p < .001$

Materials

The word-pair memory task was modelled after the task used by Naveh-Benjamin et al. (2007). During the study phase 50 word pairs were presented sequentially in black font on a white background on a laptop screen. The words were selected from the CELEX database. All words were high-frequency one- or two-syllable Dutch nouns. The two words in each pair were semantically unrelated and were not strongly related to words in other pairs. The order of the word pairs was randomized for each participant. The presentation duration of the pairs was 8 seconds with an interstimulus interval of 500 milliseconds between subsequent pairs. The study phase was followed by an immediate and a 20-minute delayed item and associative recognition test.

For the immediate recognition test, item and associative memory were measured as follows: for item recognition, 20 single words were used, 10 of which were target words and 10 were distracter words. The target and distracter words were presented in a randomized order for each participant. The associative recognition tests consisted of 20 word pairs. Ten word pairs were shown as they appeared in the study phase. The other 10 pairs consisted of rearranged pairs: all individual words were part of the word pairs in the study phase, but now rearranged into new word-pair combinations.

The delayed recognition test was almost equivalent, except for the stimuli. For the delayed recognition test, item memory was tested with 10 target and 10 distracter words, none of which were used in the immediate recognition test. Also, 10 new target and 10 new rearranged word pairs were used for the delayed associative recognition test, with none of the words being used in the immediate recognition phase.

To rule out possible order effects, two versions of the word-pair task were created with different stimuli for the immediate and delayed tests. The items and word pairs that were used for the immediate tests in version 1 were used for the delayed tests in version 2 and vice versa.

Regarding the performance scores of the word pair task, hit and false alarm rates were calculated for each participant. Hit rates were calculated by dividing the number of correct target responses by the total number of targets presented in each condition (i.e., 10). False alarm (FA) rates were calculated by dividing the number of incorrect non-target responses by the total number of non-targets (i.e., 10). For each participant Hit minus FA rates (Pr-values; Snodgrass & Corwin, 1988) were computed for each memory test: immediate item recognition, immediate associative recognition, delayed item recognition and delayed associative recognition. Hit - FA rates range from -1.0 to 1.0, with 0.0 representing chance level and 1.0 a perfect score. Hit - FA rates were used in the main analyses. Additionally, analyses were performed on Hit rates and FA rates separately.

Procedure

This study was approved by the Ethics Committee Faculty of Social Sciences (ECSS) at Radboud University. Participants were tested individually at home in a quiet room. Participants received information about the study at the beginning of the test session, signed an informed consent form and were asked for demographical information. Each test session had a duration of approximately 60 minutes. The two versions of the word-pair task were counterbalanced across the sample and within each age group.

Participants were randomly assigned to either the intentional learning or the associative strategy condition. Participants in both conditions were given the intentional learning instructions in which the participants were told to memorize both the words and the pairs for the upcoming item and associative recognition tests. The nature of the recognition tests was thoroughly explained. The participants in the associative strategy condition received an additional instruction, namely that memory performance can be improved by creating a sentence that links the two words of each pair into a meaningful representation. Participants in the associative strategy condition practised creating meaningful sentences in five word-pair examples and were strongly encouraged to use this sentence strategy during the study phase of the task. To assure that participants used the sentence strategy on each word pair, they were asked to produce the sentences out loud.

Following the task instructions, participants were able to ask questions for clarification. After answering the questions the experimenter initiated the study phase, in which participants were asked to memorize the 50 word pairs. After the study phase, two immediate recognition tests were administered on the laptop, one for item recognition and one for associative recognition. Approximately 20 minutes after the study phase the delayed recognition tests were administered. The presentation of the stimuli in all recognition tests was self-paced and response to one item was required before the next item was presented.

The 20-minute delay was filled with the administration of the Block Design test. To prevent rehearsal of the stimuli, the participants were not informed about the delayed recognition tests. After completing the delayed recognition tests, the Vocabulary subtest was administered.

Results

For the statistical analyses IBM SPSS 20.0 was used. Alpha was set at 0.05 for all analyses and two-tailed tests were used. Multiple regression analyses were performed with Hit - FA rates as dependent variable. Strategy (no strategy instructions versus strategy instructions), Age and estimated IQ were entered as predictors, as well as their 2-way and 3-way interactions. For the main research questions regarding the associative deficit in older adults, the effect of strategy instructions and the moderating role of IQ, multiple regression

analyses were performed for the immediate item and immediate associative recognition Hit - FA rates. To examine the effect of delay, similar regression analyses were performed for the delayed item and delayed associative recognition Hit - FA rates. Furthermore, to examine whether the predictors specifically affect the Hit rates, the FA rates or both, similar regression analyses were performed for Hit rates and FA rates separately. Finally, similar regression analyses for Hit - FA rates were executed with the subtests V and BD as separate measures of crystallized and fluid intelligence respectively, thereby replacing the total IQ estimate. This latter type of analyses was conducted in order to explore whether a more crystallized estimate of intelligence (V) or a more fluid estimate of intelligence (BD), or both, was more important in moderating the effect of intelligence on the beneficial effects of strategy instructions.

Immediate item and associative recognition (Hit - FA rates)

The overall models for the regression predicting immediate item and immediate associative recognition performance were significant, respectively $F(7, 132) = 5.60, p < .001$, adjusted $R^2 = .19$ and $F(7, 132) = 11.86, p < .001$, adjusted $R^2 = .35$. Table 2 shows the unstandardized and the standardized beta-coefficients for the regression analyses. Strategy and IQ were significant independent predictors for both item (respectively, $p < .001$ and $p = .004$) and associative (respectively, $p < .001$ and $p < .001$) recognition, suggesting that strategy instructions improved item and associate memory performance, and that an increase in IQ-estimate was associated with an increase in item and associative memory performance. Age was a significant predictor for associative recognition ($p = .014$), but not for item recognition. These results show that associative recognition decreases with age, whereas item recognition does not. Furthermore, the interaction between Age and IQ was a significant predictor for both item ($p = .021$) and associative ($p < .001$) recognition. Further inspection of these results show that the positive effect of IQ on memory performance was larger in younger adults than in older adults. The interaction between Age and Strategy was not significant for item ($p = .847$) or associative ($p = .958$) recognition. The interaction between IQ and Strategy was also not significant (respectively, $p = .578$ and $p = .198$).

A significant 3-way interaction between Age, Strategy and IQ was observed for associative recognition ($p = .013$), not for item recognition. To interpret the interaction, we plotted the effect of Strategy at older and younger age and higher and lower IQ levels (Figure 1). Slope difference tests showed that in adults with a lower IQ, older adults benefited less from strategy instructions than younger adults, $t = -2.64, p = .009$. In adults with a higher IQ we found the opposite effect: older adults benefited more from strategy instructions than younger adults, $t = 2.76, p = .007$. Furthermore, younger adults with a lower IQ benefited more from strategy instructions than younger adults with a higher IQ, $t = -3.82, p < .001$. Older adults with a higher and a lower IQ did not significantly differ, $t = 1.30, p = .195$.

Table 2 Main and interaction effects of Age, Strategy and IQ on Hit - FA rates of immediate item and associative recognition tests.

Predictors	Immediate item recognition			Immediate associative recognition		
	B	SE B	β	B	SE B	β
Age	-.001	.001	-.112	-.004	.002	-.266**
Strategy	.158	.033	.363***	.270	.045	.413***
IQ	.004	.001	.307**	.008	.002	.419***
Age * Strategy	.000	.002	-.021	.000	.002	.005
Age * IQ	.000	.000	-.260*	.000	.000	-.370***
Strategy * IQ	-.001	.002	-.059	-.004	.003	-.122
Age * Strategy * IQ	.000	.000	.094	.000	.000	.257*

Note. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Delayed item and associative recognition (Hit - FA rates)

The overall models for the regression predicting the delayed item and the delayed associative recognition performance levels were significant, respectively $F(7, 133) = 4.42$, $p < .001$, adjusted $R^2 = .15$ and $F(7, 133) = 14.21$, $p < .001$, adjusted $R^2 = .40$. Table 3 shows the unstandardized and the standardized beta-coefficients for the regression analyses. Results of the delayed recognition tests were similar to those of the immediate recognition tests for almost all predictors. Therefore, only additional results will be discussed here. Age was a significant independent predictor for delayed item recognition ($p = .036$), whereas it was not for immediate item recognition. These results indicate that there is no age effect on item recognition directly after encoding, but that performance decreases with age when a delay is added between encoding and recollection.

The 3-way interaction between Age, Strategy and IQ was significant for delayed associative recognition ($p = .001$). Slope difference tests were comparable to those of the immediate associative recognition. In adults with a lower IQ, older adults benefited less from strategy instructions than younger adults, $t = -2.58$, $p = .011$. In adults with a higher IQ, older adults benefited more from strategy instructions than younger adults, $t = 4.76$, $p < .001$. Younger adults with a lower IQ benefited more from strategy instructions than younger adults with a higher IQ, $t = -4.53$, $p < .001$. In addition to results of the immediate associative recognition, we found that older adults with a higher IQ benefited more from strategy instructions than older adults with a lower IQ, $t = 2.94$, $p = .004$ (Figure 2).

Furthermore, a significant 3-way interaction between Age, Strategy and IQ was found for delayed item recognition ($p = .001$), whereas this interaction was not significant for immediate item recognition. The pattern of slope differences was similar to that of the delayed associative recognition.

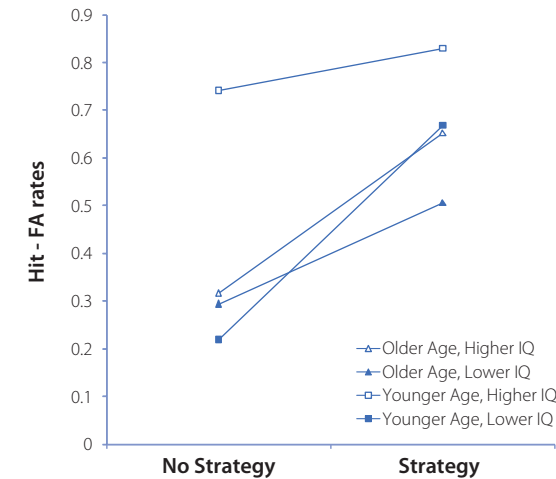


Figure 1 Age * Strategy * IQ effect on immediate associative recognition (Hit – false alarm (FA) rates). Strategy is a dichotomous measure, consisting of two groups (No Strategy, Strategy). Age and IQ are continuous measures. Graphical points represent -1 SD and + 1 SD of the mean.

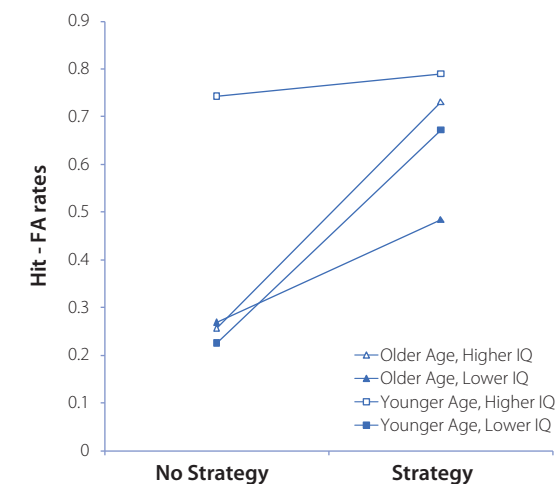


Figure 2 Age * Strategy * IQ effect on delayed associative recognition (Hit – false alarm (FA) rates). Strategy is a dichotomous measure, consisting of two groups (No Strategy, Strategy). Age and IQ are continuous measures. Graphical points represent -1 SD and + 1 SD of the mean.

Table 3 Main and interaction effects of Age, Strategy and IQ on Hit - FA rates of delayed item and associative recognition tests.

Predictors	Delayed item recognition			Delayed associative recognition		
	B	SE B	β	B	SE B	β
Age	-.003	.001	-.236*	-.006	.002	-.334***
Strategy	.124	.035	.279***	.294	.043	.447***
IQ	.003	.001	.243*	.008	.002	.382***
Age * Strategy	.003	.002	.169	.002	.002	.104
Age * IQ	.000	.000	-.257*	.000	.000	-.388***
Strategy * IQ	-.003	.002	-.152	-.002	.003	-.070
Age * Strategy * IQ	.000	.000	.388**	.000	.000	.345***

Note. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Hit rates and FA rates

Additional regression analyses were performed for Hit rates (Table 4) and FA rates (Table 5) separately. Results showed that strategy instruction significantly improves both hits and false alarms. Furthermore, an effect of IQ was observed for Hit rates in all recognition tests. For FA rates, IQ was a significant predictor for associative recognition, whereas it had no effect on item recognition. Age was a significant predictor for Hit rates in delayed recognition tests, whereas it had no effect on immediate recognition. For FA rates, we found that Age had a significant effect on associative recognition and not on item recognition.

The 3-way interaction between Age, Strategy and IQ was significant for the immediate associative and delayed associative Hit rates. The pattern of slope differences was similar to those of the Hit - FA rates. Furthermore, this 3-way interaction was significant for the delayed item and associative FA rates. For the delayed item FA rates, slope difference tests showed similar results to those of the Hit - FA rates. For the delayed associative FA rates, results showed that only younger adults with a higher IQ did not benefit from strategy instructions, whereas all others did.

Vocabulary (V) and Block Design (BD)

Finally, similar regression analyses were performed for Hit - FA rates with the subtests V and BD as independent IQ measures. Both V and BD had similar main and interaction effects on immediate and delayed item and associative recognition compared to the IQ estimate used in previous analyses. No meaningful differences were found between the effect of V and the effect of BD on Hit - FA rates, or their interaction with strategy instructions and age (Table S1).

Table 4 Main and interaction effects of Age, Strategy and IQ on Hit rates of immediate and delayed item and associative recognition tests.

Predictors	Immediate item recognition			Immediate associative recognition			Delayed item recognition			Delayed associative recognition		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Age	-.001	.001	-.106	-.001	.001	-.135	-.002	.001	-.253*	-.002	.001	-.209*
Strategy	.073	.025	.235**	.132	.031	.319***	.063	.030	.172*	.133	.028	.350***
IQ	.003	.001	.293**	.004	.001	.314**	.003	.001	.259*	.003	.001	.296***
Age * Strategy	.000	.001	-.009	-.001	.002	-.086	.003	.002	.203	.001	.001	.057
Age * IQ	.000	.000	-.211	.000	.000	-.346**	-.000	.000	-.080	.000	.000	-.328**
Strategy * IQ	-.001	.002	-.061	-.001	.002	-.054	-.003	.002	-.199	.000	.002	-.007
Age * Strategy * IQ	.000	.000	.120	.000	.000	.260*	.000	.000	.143	.000	.000	.331**

Note. Immediate item recognition: $F(7, 132) = 3.02, p = .006$, adjusted $R^2 = .09$; Immediate associative recognition: $F(7, 132) = 6.35, p < .001$, adjusted $R^2 = .21$
 Delayed item recognition: $F(7, 133) = 2.27, p = .032$, adjusted $R^2 = .06$; Delayed associative recognition: $F(7, 133) = 7.33, p < .001$, adjusted $R^2 = .24$
 * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 5 Main and interaction effects of Age, Strategy and IQ on FA rates of immediate and delayed item and associative recognition tests.

Predictors	Immediate item recognition			Immediate associative recognition			Delayed item recognition			Delayed associative recognition		
	B	SE B	β	B	SE B	β	B	SE B	β	B	SE B	β
Age	.000	.001	.049	.003	.001	.295**	.000	.001	.038	.004	.001	.318**
Strategy	-.085	.027	-.261**	-.139	.030	-.347***	-.061	.027	-.185*	-.161	.033	-.365***
IQ	-.001	.001	-.131	-.004	.001	-.361**	.000	.001	-.041	-.004	.001	-.314**
Age * Strategy	.000	.001	.020	-.001	.002	-.097	-.000	.001	-.003	-.002	.002	-.106
Age * IQ	.000	.000	.146	.000	.000	.247*	.000	.000	.257*	.000	.000	.295**
Strategy * IQ	.000	.002	.020	.003	.002	.143	.000	.002	-.015	.002	.001	.099
Age * Strategy * IQ	-.006	.000	-.010	.000	.000	-.151	.000	.000	-.363**	.000	.000	-.229*

Note: Immediate item recognition: $F(7, 132) = 1.95, p = .067$, adjusted $R^2 = .05$; Immediate associative recognition: $F(7, 132) = 6.85, p < .001$, adjusted $R^2 = .23$
Delayed item recognition: $F(7, 133) = 2.08, p = .050$, adjusted $R^2 = .05$; Delayed associative recognition: $F(7, 133) = 7.42, p < .001$, adjusted $R^2 = .24$
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Discussion

This study examined the effect of strategy instructions on memory performance across the adult lifespan, with specific interest in the role of IQ. The present study extended previous findings through some methodological improvements, such as including participants across the adult life span, adding a delay condition to the word-pair task and including an IQ estimate as moderator. Consistent with the associative deficit hypothesis, associative recognition decreased with age, whereas item recognition did not (Naveh-Benjamin, 2000; Old & Naveh-Benjamin, 2008). When analyzing hits and false alarms separately, we found that age had an effect on false alarms in the associative recognition tests, whereas it had no effect on item recognition. For hit rates, age was related to both item and associative recognition, but only at delayed testing. We thereby confirmed that the associative deficit in older adults is mainly caused by an aging-related increase in false alarms, rather than a decrease in hits (Bender et al., 2010; Castel & Craik, 2003; Shing, Werkle-Bergner, Li, & Lindenberger, 2009). Furthermore, a strong effect of strategy instructions was present in all conditions, indicating that both item and associative recognition increase when the sentence generation strategy is used. Moreover, strategy instructions affect both the identification of targets (hits) and the rejection of lures (false alarm) in an equal manner (Shing et al., 2009). With respect to the delayed recognition tests we found the same pattern of results as for the immediate recognition tests. However, an additional effect of age was found for the delayed item recognition, indicating that item recognition decreases with age when a delay is added between encoding and recollection (Davis et al., 2003). Nonetheless, the effect of age remained stronger for associative recognition.

Regarding the main focus of this study, we found that IQ moderates the effect of strategy instructions on associative memory performance in aging. In younger adults, those with a lower IQ benefited more from strategy instructions than those with a higher IQ, who did not improve at all. In older adults this pattern was reversed: here, those with a higher IQ benefited more from strategy instructions than older adults with a lower IQ. At delayed testing older adults with a higher IQ benefited to such extent that they reached the performance level of younger adults with a higher IQ.

By taking IQ into account, this study extends previous findings regarding strategy use in aging. When focusing on adults with a higher estimated IQ we find that the beneficial effects of strategy instructions are absent at a younger age, but increase with advancing age, which is in agreement with the findings of Naveh-Benjamin et al. (2007), who only included participants with a relatively high level of general cognitive ability. However, when the results of older adults with different IQ levels are taken together we find similar beneficial effects of strategy instructions for younger and older adults, in line with the results of Shing et al. (2008). Therefore, IQ appears to underlie these seemingly contradicting results.

Table S1 Main and interaction effects of Age, Strategy and IQ on Hit - FA rates of immediate and delayed item and associative recognition tests. The two WAIS-III subtests Vocabulary (VOC) and Block Design (BD) were separately included as proxy for IQ.

	Immediate item recognition		Immediate associative recognition		Delayed item recognition		Delayed associative recognition	
	β VOC	β BD	β VOC	β BD	β VOC	β BD	β VOC	β BD
Age	-.141	-.110	-.299**	-.245*	-.251*	-.230*	-.355***	-.317**
Strategy	.323***	.367***	.364***	.428***	.266**	.276***	.400***	.457***
IQ (VOC or BD)	.418***	.124	.353***	.369***	.182	.184	.364***	.307**
Age * Strategy	.013	-.028	.037	-.012	.145	.169	.114	.095
Age * IQ	-.295**	-.100	-.331**	-.279*	-.245*	-.235	-.327**	-.300**
Strategy * IQ	-.260*	.080	-.135	-.115	-.083	-.146	-.122	-.056
Age * Strategy * IQ	.162	.040	.230*	.243*	.394**	.321*	.287**	.328**

p* < .05; *p* < .01; ****p* < .001.

Several explanations have been put forward with respect to the workings of IQ on the effect of strategy instructions. One notion suggests that a higher IQ is associated with more spontaneous and efficient strategy use (Barulli et al., 2013). In the present study, younger adults with a higher IQ estimate presumably used efficient strategies spontaneously, and therefore did not benefit from additional strategy instructions (Dirette, 2015). In contrast, younger adults with a lower IQ estimate might have used less strategies spontaneously and therefore did benefit from strategy instructions. Furthermore, in adults with a higher IQ estimate the beneficial effects of strategy instructions increased with age. This finding could be explained by the production deficiency hypothesis, which states that spontaneous strategy use decreases with age (Dunlosky et al., 2005; Glisky, Rubin, & Davidson, 2001) and the environmental support hypothesis, which declares that with sufficient environmental support, older adults are able to implement the provided strategies (Froger et al., 2012). However, these theoretical models do not explain the finding that in adults with a lower IQ this pattern is reversed: the beneficial effects of strategy instructions decrease with age.

Another explanation that could account for the fact that older adults with a lower IQ estimate only showed a small benefit from strategy instructions focuses on the ability to process the provided strategies efficiently. The older adults with a higher IQ estimate in our study were able to apply the provided strategies and compensate for their memory decrements to such extent that their memory performance almost reached the performance level of younger adults, which was also demonstrated by Naveh-Benjamin and colleagues (2007). In adults with a lower IQ the beneficial effects of strategy instructions decreased with age, which can be explained by an aging-related decline in cognitive resources that are needed to implement the proposed strategy efficiently. According to the processing deficiency hypothesis older adults have difficulties incorporating strategies efficiently, even when associative strategies are provided (Dunlosky & Hertzog, 1998; Hertzog, Price, & Dunlosky, 2012). However, the present study suggests that it is highly dependent on IQ whether or not older adults are able to process and apply these strategies efficiently.

These findings are consistent with the study of Nyberg et al. (2003), which suggests that cognitive reserve (CR) capacity may influence both the production efficiency (e.g. spontaneous strategy use) and the processing efficiency (e.g. efficient use of provided strategies) in older adults. Previous studies have used an IQ estimate as proxy for CR (Alexander et al., 1997; Galioto, Alosco, Spitznagel, Stanek, & Gunstad, 2013; Farinpour et al., 2003), however often a combination with education level, occupational attainment and engagement in cognitively stimulating leisure activities is used (Opdebeeck, Martyr, & Clare, 2016). As such, also in our study a higher IQ estimate may be indicative of higher levels of CR. CR is known to play an important role in compensating for the consequences of aging-related brain changes by using compensatory cognitive processes (Stern, 2002, 2009). With respect to memory problems, individuals with a higher CR are more likely to

compensate for deficits in memory networks by using other cognitive resources, such as memory strategies. Moreover, previous studies have shown that individuals with a higher CR have a lower risk of developing a dementia at older age, as efficient compensatory mechanisms may enable them to function independently for a longer period of time (Dekhtyar et al., 2015; Stern, 2012). Developing effective interventions targeting compensatory mechanisms for aging-related memory decline is therefore important. In a literature review, Metternich, Kosch, Kriston, Harter, & Hull (2010) concluded that compensatory cognitive training, aimed at acquiring and applying memory strategies, is effective in older adults. Whether this type of strategy training is particularly effective for older adults with a higher or lower CR should be investigated in further research. Presumably, more practice sessions are needed for older adults with a lower CR to incorporate these strategies efficiently. Furthermore, older adults with a lower CR might benefit more from the use of external memory aids (e.g., alarm, calendar) than from using internal memory strategies (e.g., associations), as the use of memory aids is cognitively less demanding (Bouazzaoui et al., 2010). One could argue that the sentence generation strategy that was used in this study might be unsuitable for older adults with a lower IQ, since the efficacy of the strategy depends on the meaningfulness and complexity of the sentence that is generated (Richardson, 1998). In the present study the generated sentences were not recorded, therefore no further analyses on the effect of sentence complexity could be performed. Future research should confirm whether older adults with a lower CR are less able to generate meaningful and complex sentences than those with a higher CR, and whether such potential difference could account for the finding that older adults with a lower IQ estimate profited to a lesser extent from the strategy instructions. Nonetheless, when using strategy interventions to compensate for the aging-related decline in memory it is important to adjust the interventions to the CR levels of the participants.

Some limitations of our study should be noted. Since we did not measure spontaneous strategy use directly we cannot confirm whether our participants with a lower IQ estimate used less strategies spontaneously. Future studies that explicitly observe spontaneous strategy use in adults with different levels of IQ or other measures of CR are needed. Furthermore, our interpretations are restricted to the associative strategy used in this study (sentence generation) and may not necessarily extend to other memory strategies (e.g., visual imagery). Also, the word pairs used in this study consisted of familiar, simple words that were relatively easy to associate. The study of Shing et al. (2008) has shown that the associative deficit of older adults may be more pronounced under associatively demanding conditions, with smaller effects of strategy instructions and practice. Future studies should examine whether older adults with a higher CR still benefit from strategy instructions in more demanding conditions. Another limitation is the use of an IQ estimate, which was based on a dyadic short form of the WAIS-III, rather than the use of a full intelligence test battery. Although this dyadic short form is known to have strong correlations with Wechsler's FSIQ and appears to be reliable to estimate gross overall

intelligence, it is recommended to be cautious when interpreting exact levels of intelligence (Ringe et al., 2002). Moreover, it would be of interest to examine potential differences between measures of crystallized and fluid intelligence, given their separate abilities and potential effects on strategy use. Whereas crystallized intelligence relies on acquired declarative and procedural knowledge, fluid intelligence is based on controlling mental operations and problem solving abilities (Carroll, 1993) and has been associated with creativity (Nusbaum & Silvia, 2011). Previous studies have related either measures of fluid intelligence (Ariel, Price, & Hertzog, 2015) or measures of crystallized intelligence (Barulli et al., 2013) to efficient memory strategy use, however, their effects have never been compared directly. A first attempt in this study, by distinguishing between V and BD subtests in relation to the effect of strategy use, did not show meaningful differences in the effect of these two diverse intelligence subtests. A more thorough study, including multiple measures of crystallized and fluid intelligence, is required to elucidate this question.

To summarize, this study is the first to demonstrate that IQ plays a crucial role in the proficient effects of strategy instructions on memory across the adult lifespan. Specifically, older adults with a higher IQ estimate profited substantially from strategy-instructions, whereas those with a lower IQ estimate profited to a lesser extent. Moreover, the present study demonstrated an aging-related decline in associative memory. When adding a delay between encoding and recollection, this aging-related decline is also present for item memory. This study highlights the importance of the role of IQ in compensating for the aging-related decline in associative memory. Future studies are needed to examine the extent to which IQ or other CR measures influence the strategy production deficiency and the strategy processing deficiency in older adults.



Chapter 4

Memory strategy use in older adults with subjective memory complaints

Published as

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Abstract

Background: Subjective memory complaints (SMC) are common among older adults, but, it is unclear to what extent adults with SMC spontaneously use memory strategies to compensate for their memory problems. As SMC may be a risk factor for memory decline later, it is important to extend our knowledge about spontaneous compensatory mechanisms in older adults with SMC.

Methods: Self-reported and observed strategy use were assessed in 38 adults with and 38 without SMC.

Results: Adults with SMC used more strategies in daily life than those without. In the SMC group, memory complaints were positively correlated with strategy use. Only in adults without SMC a significant correlation was found between observed strategy use and task performance.

Conclusions: Strategy use in older adults with SMC may be compensatory in nature, but did not increase their objective memory performance. Therefore, older adults with SMC might benefit from interventions aimed at optimizing strategy use.

Introduction

Older adults with subjective memory complaints (SMC) experience a decline in memory functioning, without evidence for objective cognitive impairments or an underlying neurodegenerative disease or psychological disorder (Jungwirth et al., 2004). Although the experienced decline lies within the normal limits of cognitive aging, it negatively influences everyday functioning and quality of life (Montejo, Montenegro, Fernandez, & Maestu, 2011). Moreover, older adults with SMC have an increased risk for future cognitive decline and dementia (Luck et al., 2015), which stresses the need for early intervention.

Many interventions targeting SMC incorporate strategy training aimed at compensating for the memory decline (Metternich, Kosch, Kriston, Harter, & Hull, 2010). However, it is unclear to which extent older adults with SMC spontaneously use strategies to cope with their memory complaints. To improve interventions it is important to gain more insight in spontaneous memory strategy use. Memory strategies can be divided into internal and external strategies (Dixon & Hultsch, 1983). Internal strategies include mental encoding or retrieval strategies, such as rehearsal or visual imagery. External strategies are memory aids supporting memory function, such as using a calendar or taking notes. Previous studies on healthy aging have shown that it is specifically external strategy use that increases with age (Bouazzaoui et al., 2010), presumably because the use of external aids requires little cognitive control and can easily be incorporated in daily life. In addition, adults with SMC recruit additional neural networks during memory encoding (Erk et al., 2011; Rodda, Dannhauser, Cutinha, Shergill, & Walker, 2009), suggesting the use of compensatory cognitive functions. However, to date it is unclear whether adults with SMC also use more strategies in daily life and to what extent spontaneous strategy use is associated with better memory performance on objective tests.

The present study examined memory strategy use in older adults with SMC and those without SMC. We expected both groups to use relatively more external than internal strategies (Bouazzaoui et al., 2010) and expected older adults with SMC to use more strategies than those without (Erk et al., 2011; Rodda et al., 2009). Furthermore, strategy use has been related to education level, premorbid IQ and memory performance (Barulli, Rakitin, Lemaire, & Stern, 2013; Dunlosky & Hertzog, 1998; Frankenmolen et al., 2017). Therefore, in both groups, correlation analyses were performed with these variables.

Methods

Participants

The participants of this study comprised 38 older adults with Subjective Memory Complaints (SMC) and 38 healthy older adults without SMC. All participants were aged between 50 and 85 and lived independently in the community. Exclusion criteria were

severe psychiatric problems, neurological disorders, substance abuse and objective cognitive impairment. The participants with SMC were recruited from three outpatient memory clinics in the Netherlands: Radboudumc Nijmegen, Canisius-Wilhelmina Hospital Nijmegen and Gelre Hospitals Zutphen, in the context of an ongoing study on the effects of a memory training. Patients were classified as having SMC by a multidisciplinary team of clinical specialists. Neuropsychological assessment was used as a supplementary tool to exclude clinical diagnoses such as Mild Cognitive Impairment, dementia or psychiatric disorders. The older adults without SMC consisted of community-dwelling elderly who were recruited through advertisement and were screened over the telephone for exclusion criteria and for subjective memory complaints.

Table 1 shows the characteristics of the participants. Education level was rated according to the International Standard Classification of Education (ISCED 2011) of the United Nations Educational, Scientific and Cultural Organisation Institute for Statistics (UNESCO-UIS). IQ was estimated using the Dutch version of the National Adult Reading Test (NART). Memory complaints were assessed using a 30-item memory complaint inventory on which participants indicated the frequency of memory failures using a 5-point scale (Deelman & Saan, 1990). Inclusion of participants with SMC was part of a memory training study and was approved by the Medical Review Ethics Committee region Arnhem-Nijmegen (No. NL43519.091.013). Inclusion of the adults without SMC was approved by the Ethics Committee Faculty of Social Sciences (ECSS) at the Radboud University in Nijmegen.

Table 1 Descriptive Characteristics of Sample.

Variable	Group	
	SMC- M (SD)	SMC+ M (SD)
N	38	38
Age	64.24 (8.92)	67.45 (7.40)
Sex M/F	20 / 18	18 / 20
Education	3.60 (2.01)	4.34 (1.89)
IQ estimate	106.84 (17.83)	106.00 (15.83)
Memory complaints	60.11 (13.58)	79.16 (14.94)
SOT story recall	8.95 (4.30)	8.36 (3.95)

Note. SMC+ = group with subjective memory complaints; SMC- = group without subjective memory complaints; SOT = strategy observation task.

Materials

Strategy Use Inventory (SUI)

The Strategy Use Inventory (Koning-Haanstra, Berg, & Deelman, 1990) measures strategy use in daily life with two subscales. The subscale External Strategies consists of 6 items and includes the use of memory aids, such as taking notes or using a calendar. The subscale Internal Strategies consists of 8 items and includes mnemonics such as mental rehearsal or creating associations. Participants had to indicate how often they use a certain strategy by rating items on a 5-point Likert scale. Average items scores were calculated for each subscale.

Strategy Observation Task (SOT)

The Strategy Observation Task (SOT) was developed in order to observe strategy use during a memory task that mimics daily life situations. Participants were instructed to remember a story (21 elements) that was presented as an audio clip. Story C of the Rivermead Behavioural Memory Test (RBMT; Wilson, Cockburn, & Baddeley, 1985) was used for this purpose. Additionally, participants were asked to spontaneously recall the story exactly 5 minutes after the end of the audio clip. In the meantime they were instructed to solve basic math problems. The instructions emphasized that participants should remember as much information as possible and that they were allowed to do or use anything to help them remember the information. A pen, paper and an alarm clock were available within reaching distance. During the instruction music was playing in the background. The volume of this music was pre-set at a level at which it was clearly distracting, but making sure that all instructions could still be understood. When asked, or at the start of the audio clip, the music was turned off. Strategic behaviour of the participants was recorded on an observation list. Examples of possible strategies were asking questions about instructions, asking to turn off the music, taking notes or setting an alarm. The total number of observed strategies was calculated for each participant.

The recall of the story ideally took place five minutes after the end of the audio clip. When participants did not recall the story spontaneously seven minutes after the end of the audio clip, they received a cue. The SOT story recall score consisted of the number of correctly reproduced elements.

Statistical analysis

For the statistical analyses IBM SPSS 21.0 was used. Alpha was set at 0.05 for all analyses, one-tailed testing was used for directed hypotheses. Demographic variables of participants with and without SMC were compared using nonparametric, chi square or t-tests. Subsequently, a 2 (group; between-subjects) \times 2 (strategy type; within-subjects) mixed ANOVA was performed with ratio scores of the strategy use inventory as dependent variable. Furthermore, an univariate ANOVA was performed with group as independent variable and observed strategy use on the SOT as dependent variable. Finally, correlations

were computed to examine whether education, IQ estimate, memory complaints and story recall correlated with strategy use in each group.

Results

No between/group differences were found with respect to age ($t(74) = -1.71, p = .092$), sex distribution ($\chi^2(1) = 0.65, p = .819$), education level ($U = 890.50, p = .072$), IQ estimate ($t(74) = 0.22, p = .828$) and SOT story recall ($t(73) = 0.61, p = .544$). As expected, the SMC group reported significantly more memory complaints than the group without SMC ($t(74) = -5.82, p < .001$).

A significant main effect of strategy type ($F(1, 74) = 18.41, p < .001$, one-tailed) was found, in which the use of external strategies ($M = 3.58, SD = 0.56$) was more frequent than the use of internal strategies ($M = 3.19, SD = 0.82$) in both groups. The interaction between strategy type and group was not significant ($F(1, 74) = 0.41, p = .523$). Furthermore, a main effect of group was found for strategy use ($F(1, 74) = 3.67, p = .030$, one-tailed), in which the SMC group ($M = 3.51, SD = 0.64$) reported using more strategies than the individuals without SMC ($M = 3.26, SD = 0.72$). Regarding the SOT, an ANOVA showed no main effect of group ($F(1, 73) = 0.05, p = .411$), indicating that both groups used the same amount of strategies during the SOT.

Table 2 shows the Spearman rank correlations between education, IQ estimate, EF, memory complaints, story recall and the strategy measures. In the SMC group, memory complaints were strongly associated with internal and external strategy use. Those who experienced more memory complaints also reported using more strategies in daily life. These correlations were not significant in the individuals without SMC. Education level and IQ did not correlate significantly with any of the strategy measures. The number of observed strategies during the SOT correlated positively with the story recall score in the individuals without SMC only; those who used more strategies had a better recall score.

Table 2 Spearman correlations between participant characteristics and strategy measures in older adults without (SMC-) and in older adults with subjective memory complaints (SMC+).

	Strategy measures					
	SMC-			SMC+		
	Internal	External	SOT	Internal	External	SOT
Education	.31	.20	.24	.29	.05	.12
IQ estimate	.28	.23	.06	.05	-.02	-.17
Memory complaints	.30	.19	.31	.54***	.50**	-.19
SOT story recall	.25	.24	.37*	.11	-.10	.23

Note. SOT = strategy observation task.

* $p < .05$; ** $p < .01$; *** $p < .001$

Discussion

This study examined memory strategy use in older adults with and without SMC. Both groups used more external than internal strategies in daily life, which is consistent with previous findings in aging (Bouazzaoui et al., 2010). Furthermore, the older adults with SMC reported using more memory strategies in daily life than the individuals who did not experience SMC. Moreover, strong correlations were found between the amount of memory complaints and strategy use within the SMC group. Although none of the participants in the SMC group had any clinically relevant deficits as measured with neuropsychological tests, they may encounter problems in daily-life tasks that require a complex interaction of cognitive skills (Pike, Zeneli, Ong, Price, & Kinsella, 2015). The increased strategy use may reflect a compensatory approach, in line with recent evidence showing that participants with SMC recruit additional, compensatory neural networks for successful cognitive performance compared to older adults without SMC (Erk et al., 2011; Rodda et al., 2009).

This explanation, however, is at odds with the finding that observed strategy use was unrelated to the actual memory performance in the SMC group, in contrast to results in the group without SMC. Although further research is needed, it could be argued that older adults with SMC use strategies less efficiently than those without SMC. Previous results indeed showed that older adults with SMC benefitted less from a provided strategy during encoding than individuals without SMC (Pike et al., 2015), suggesting that they have difficulties implementing the provided strategy.

These findings may have consequences for interventions including strategy training. Since older adults with SMC already use more strategies in daily life, the utility of offering strategy training to people with SMC might be questioned. However, our results also

show that the spontaneous increase in strategy use in itself does not ameliorate their complaints, possibly because strategy use in older adults with SMC is less efficient. An important aspect of older adults with SMC is that they often have an exaggerated memory-related achievement motivation and experience little control over their memory problems (Metternich, Schmidtke, & Hull, 2009). Therefore, interventions including expectancy modification and strategy training aimed at coping with memory problems in daily life could help older adults to optimize their strategy use and gain more control over their memory functioning. A limitation of previous intervention studies, however, is that none included measures of strategy use and subjective memory functioning in daily life (Metternich et al., 2010), thereby lacking information on the efficacy of memory strategy training. Future studies should examine whether older adults with SMC benefit from such interventions and whether they are able to implement the strategies in daily life.

This study is the first to examine spontaneous strategy use in older adults with SMC. Measures included both self-reported strategy use in daily life and task-related strategy use using the SOT. However, the SOT was limited to observable, mostly external, strategies during a memory task. Future research should also include measures of various internal strategies during encoding, such as sentence generation or visual imagery (Dunlosky & Hertzog, 1998), since these strategies are known to enhance task performance.

Conclusion

This study shows that older adults with SMC may compensate for their experienced memory decline by using more compensatory strategies in daily life. However, increased strategy use did not correlate with performance on a memory task in adults with SMC, suggesting that the strategy use in older adults with SMC may not be as efficient as in older adults without SMC.



Chapter 5

Memory strategy training in older adults with subjective memory complaints: a randomized controlled trial

Submitted for publication as

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Abstract

Background: Subjective memory complaints (SMC) in older adults are associated with a decline in everyday functioning and an increased risk for future cognitive decline. This study examines the effect of a memory strategy training compared to a control memory training on memory functioning in daily life.

Methods: This was a randomized controlled trial with baseline, post-treatment and 6-month follow-up assessments conducted in 60 older adults (50-87 years) with SMC. Participants were randomly assigned to either 7 sessions of memory strategy training or 7 sessions of control memory training. Both interventions were given in small groups and included psycho-education. Primary outcome measure was memory functioning in daily life. Objective measures of memory performance and self-reported measures of strategy use were included as secondary outcome measures.

Results: Participants in each intervention group reported less memory complaints ($p=.040$) and reported an improvement in personal memory goals ($p<.001$), up to 6 months after training. An interaction effect showed that participants following memory strategy training reported a larger improvement in personal memory goals ($p=.001$). Both intervention groups improved on two memory tests ($p<.001$ and $p<.01$). In the memory strategy training group, an increase in strategy use in daily life was the strongest predictor ($p<.05$) of improvement in subjective memory functioning.

Conclusions: Older adults with subjective memory complaints benefit from memory strategy training, especially in their memory functioning in daily life.

Introduction

Subjective memory complaints (SMC) in older adults are associated with a decline in everyday functioning and quality of life (Balash et al., 2013; Jessen et al., 2014; Montejó, Montenegro, Fernandez, & Maestu, 2011). Although their cognitive functioning lies within the limits of normal cognitive aging, older adults with SMC have an increased risk for future cognitive decline and dementia (Luck et al., 2015; Mendonça, Alves, & Bugalho, 2016; Mitchell, Beaumont, Ferguson, Yadegarfar, & Stubbs, 2014), which stresses the need for early intervention.

Studies on brain training or working memory training have shown promising results on memory performance, but generalization to daily life functioning is limited (Owen et al., 2010; van Heugten, Ponds, & Kessels, 2016). Psychoeducation, cognitive restructuring and training of multiple memory strategies seem most effective in older adults with SMC, but most studies to date lack methodological quality (e.g., no RCT or lacking an active control group). Further research on generalization to daily life functioning is thus required (Gross et al., 2012; Metternich, Kosch, Kriston, Härter, & Hüll, 2010).

The present study examines the effect of a memory strategy training, including psychoeducation and strategy training, compared to a control memory training in older adults with SMC. The primary hypothesis is that memory functioning in daily life improves up to six months after training, with a larger improvement for memory strategy training. Furthermore, we expect similar effects for the secondary outcome measures, that is, performance on memory tests, strategy use in daily life and quality of life. In addition, this study examines possible predictors for improvement following treatment.

Methods

Participants

Sixty older adults (31 men) with Subjective Memory Complaints (SMC) were included in the present study. All participants were aged between 50 and 87, lived independently in the community and fulfilled current diagnostic criteria for subjective cognitive impairment (Jessen et al., 2014). Exclusion criteria were severe psychiatric problems, neurological disorders, substance abuse and objective cognitive impairment. Fifty-four participants were recruited in collaboration with three outpatient memory clinics in the Netherlands, namely the Radboud University Medical Centre and Canisius-Wilhelmina Hospital in Nijmegen and Gelre Hospitals in Zutphen. Patients were classified as having SMC by a multidisciplinary team of clinical specialists. Neuropsychological assessment using established normative data was used as a tool to control for cognitive deficits and exclude clinical diagnoses such as Mild Cognitive Impairment, dementia or psychiatric disorders. In addition, 6 participants with SMC were recruited through advertisement and screened

over the telephone for exclusion criteria using the Telephone Interview Cognitive Status (TICS; Kempen, Meier, Bouwens, van Deursen, & Verhey, 2007). Educational level was rated according to the International Standard Classification of Education (ISCED) of the United Nations Educational, Scientific and Cultural Organisation Institute for Statistics (UNESCO-UIS). Based on previous research examining the effects of memory training in adults with SMC (Metternich et al., 2010), a sample size of 30 participants in each group was required to detect a medium effect size with a power of 0.80 and alpha set at 0.05.

Procedure

This study was approved by the Medical Review Ethics Committee region Arnhem-Nijmegen (CMO #NL43519.091.013). The randomized, controlled trial is reported in accordance with the CONSORT guidelines (Altman et al., 2001). Participants gave written informed consent and all data was obtained in compliance with the Helsinki Declaration. Figure 1 displays the study procedure and the flow of participants throughout the trial. Randomization was performed per group of 3 to 5 participants using Random Allocation Software (RAS; <http://randomallocatio.sourceforge.net>). Each group of participants was randomly allocated to either the memory strategy training or the control memory training. The allocation was performed by the first author in the order of recruitment using randomly generated sequences. Assessments were performed by trained psychology students at baseline (T0), post-training (T1) and at a 6-month follow-up (T2). Both participants and students were blinded for treatment condition. Participants were told that two types of memory training were compared, without further specification. The trainer was blinded for baseline assessment measures.

Interventions

The aim of this study was to examine the effect of memory strategy training compared to an active control condition. Therefore, other training variables were kept as equal as possible. Both interventions were given in groups of 3 to 5 participants, consisted of 7 sessions (once a week) with a duration of 90 minutes per session and all participants were trained by the first author. Furthermore, in the first session all participants received psychoeducation on memory functioning and aging, and were able to share their experiences regarding memory complaints. Differences between subjective aging-related memory complaints and dementia were explained and participants were informed that their memory functioning (based on neuropsychological tests) was normal for their age. In addition, participants learned about the relation between stress, anxiety and memory complaints. Subsequently, participants were asked to formulate three personal training goals in cooperation with the trainer. An overview of the training sessions is shown in Figure 1.

Memory strategy training

The training protocol of Koning-Haanstra, Berg, and Deelman (1990) was shortened and adjusted to the particular needs of older adults with SMC. During this training, memory strategies were explained, demonstrated and exercised in each session. Both external and internal memory strategies were addressed. External strategies consist of the use of memory aids, such as taking notes or using a calendar. Internal strategies include mnemonics, such as mental rehearsal or creating associations. For an overview of the strategies that were trained in each session, see appendix 1. During the exercises, participants practiced the application of a strategy to daily life situations and their personal memory failures. Additionally, homework exercises were given in which participants had to apply the learned strategies in daily life situations.

Control memory training

For the active control memory training the computer program COGPACK® (<http://marker-software.com>) was used. Participants practised various attention and memory tasks, without any suggestions for strategies to deal with these tasks.

Outcome measures

Primary outcome measures

The primary outcome measure was memory functioning in daily life, which includes two self-report measures. First, we used personal goal ratings, an adapted measure from Koning-Haanstra et al. (1990). Participants were asked to formulate three individual personal goals in terms of their most bothersome memory complaints. For example, "I want to remember the name of someone I meet" or "I want to remember where I left my keys or phone". Subsequently, participants were asked to rate each personal goal, indicating how often they currently remembered the item in their goal. For example, "how often do you remember the name of someone you meet?". Scores ranged from 1 (never) to 10 (always). For each participant the average rating of the three goals was calculated.

In addition, subjective memory complaints were assessed using a 30-item memory complaint inventory, on which participants indicated the frequency of memory failures (Deelman & Saan, 1990). Participants had to indicate how often they experience each memory failure using a 5-point rating scale ranging from 1 (never) to 5 (often).

Secondary outcome measures

Memory functioning was assessed using the Rivermead Behavioural Memory Test – Third Edition as a measure of performance on everyday memory tasks (RBMT-3; Wilson et al., 2008). The General Memory Index (GMI) was used as a measure for everyday memory. In addition, the Location Learning Test (LLT) was used as a measure of visuospatial memory

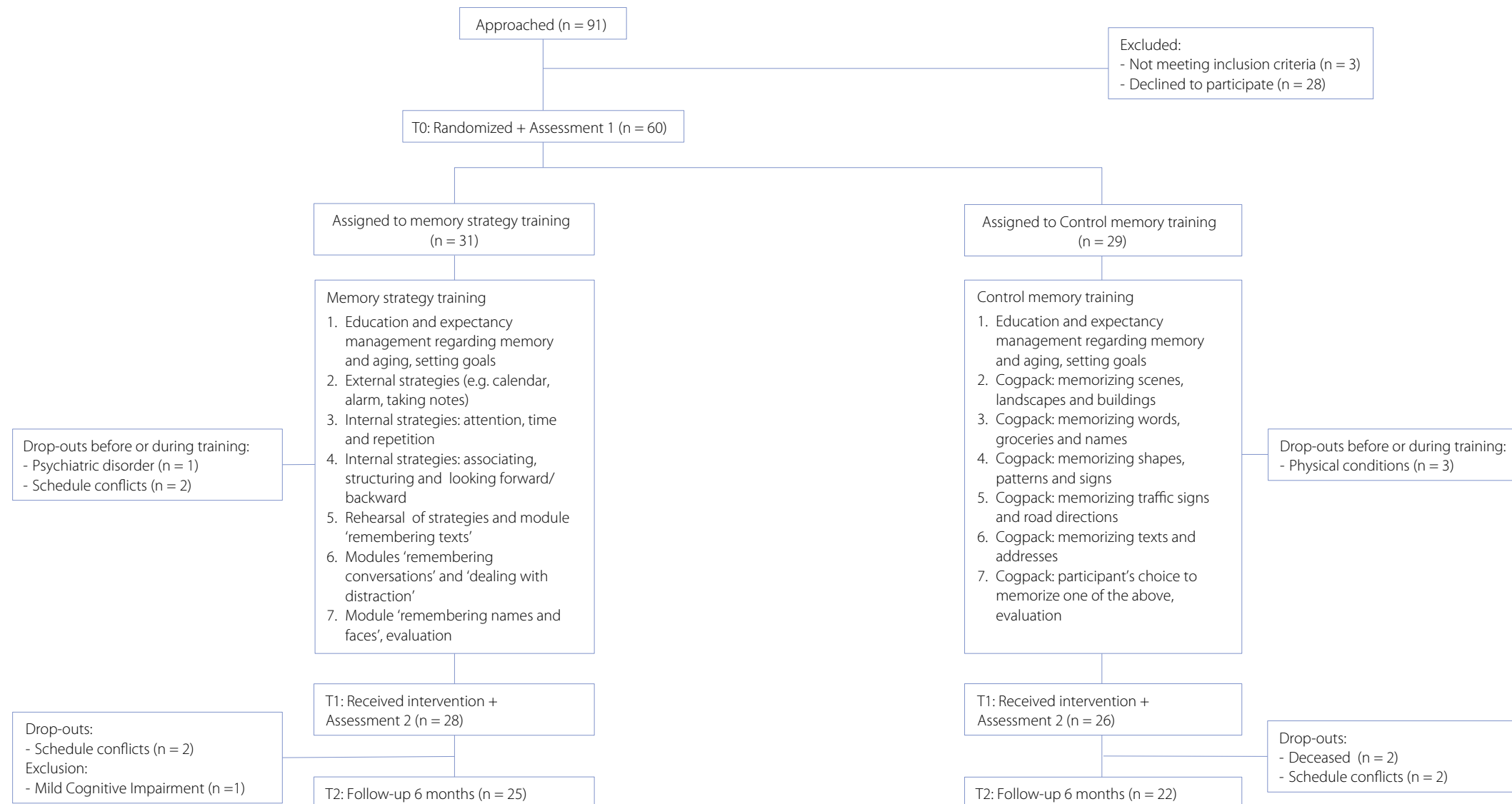


Figure 1 Flowchart of participants and overview of the training sessions for the memory training trial.

(Bucks, Willison, Byrne, & Kessels, 2011). The total displacement score on the five learning trials, the learning index and the delayed recall score were computed. Furthermore, the Rey Auditory Verbal Learning Test (RAVLT; Van der Elst, van Boxtel, van Breukelen, & Jolles, 2005) was used as a measure for verbal memory. For the RAVLT, the total score on the five learning trials and the delayed recall score were computed.

Memory strategy use was assessed through the Strategy Use Inventory; SUI (Koning-Haanstra et al., 1990). The SUI includes a subscale for external strategy use and for internal strategy use. Participants had to indicate how often they use a certain strategy in daily life situations using a 5-point rating scale ranging from 1 (never) to 5 (often). The scores on each subscale were computed.

The RAND 36-item Short Form Health Survey (RAND-36; Brazier et al., 1992), was included as a self-report measure for quality of life.

Other neuropsychological tests and questionnaires

Several executive function tests were examined at baseline to obtain a cognitive profile of the participants. The “D-A-T” letter fluency test (Schmand, Groenink, & Van den Dungen, 2008) was used to measure verbal fluency, the Trail Making Test; TMT (Lezak, Howieson, Bigler, & Tranel, 2012) for cognitive flexibility and the Digit Span subtest from the Wechsler Adult Intelligence Scale - Fourth Edition (WAIS-IV; Wechsler, 2008) to measure working memory. IQ was estimated using the Dutch version of the National Adult Reading Test (NART; Nelson, 1982). The Geriatric Depression Scale -15 (GDS-15; Sheikh & Yesavage, 1986) was used as a self-report measure of mood and the Instrumental Activities of Daily Living scale (IADL; Lawton & Brody, 1969) as a self-report measure of daily functioning.

Statistical analyses

For the statistical analyses IBM SPSS 21.0 was used. Demographic and baseline data of the two groups were compared using nonparametric, chi square or t-tests.

The main analysis consisted of a 2 (group; between-subjects) \times 3 (time; within-subjects) mixed (multivariate) ANOVA for all outcome measures. Analyses were conducted on an intention-to-treat (ITT) basis (Gupta, 2011). In case of missing outcomes, the last observation carried forward method was used. Furthermore, the proportion of patients who achieved a clinically significant improvement (i.e., an improvement of at least two standard deviations from the baseline mean; Evans, Margison, & Barkham, 1998; Jacobson & Truax, 1991) was computed for each group.

In order to examine the predictors for improvement following treatment, difference scores for T2-T0 and T1-T0 were calculated for the primary outcome measures (i.e., personal goal ratings and subjective memory complaints). Linear regression analyses were performed within each treatment group with age, IQ, education level and the difference in strategy use (T1-T0) as possible predictors for improvement following treatment, measured by the increase in personal goal ratings and decrease in subjective memory complaints.

Alpha was set at 0.05 for all analyses. Directed hypotheses regarding the primary outcome measures were tested one-tailed. Secondary outcome measures were tested two-tailed.

Results

Between October 2013 and April 2016, we approached 81 patients with a SMC diagnosis. All patients were eligible, but 27 patients declined to participate (schedule conflicts, or not interested in participating in a study). Additionally, 10 older adults with SMC were screened as result of the advertisement. Of these, 7 fulfilled the inclusion criteria, 1 of whom declined to participate. The remaining 60 participants were randomly assigned to the memory strategy training group ($n = 31$) or the control memory training group ($n = 29$). Three participants in each group withdrew from the study after baseline assessment or during treatment. Another three participants in each group did not complete the follow-up assessment. As one participant progressed to Mild Cognitive Impairment, this participant was excluded at the follow-up assessment. Figure 1 shows the flow of the participants through the trial.

Table 1 shows the demographic characteristics and baseline results for both groups. A group difference was found in sex distribution ($\chi^2(1) = 6.64, p = .019$), with relatively more men in the memory strategy training group and more woman in the control memory training group. Sex was however not significantly related to any of the outcome measures ($p > .05$), therefore it was not included in further analyses. Other demographic features (age, estimated IQ, and years of education) did not differ between the two groups. Furthermore, no group differences were found on neuropsychological tests, personal goal ratings or questionnaires at baseline. Results for the primary and secondary outcome measures at T0, T1 and T2 are reported in Table 2.

Training effects on primary outcome measures

Personal goal ratings

Figure 2 shows a significant time effect in both groups ($F(2, 53) = 64.70, p < .0005$) and a significant interaction effect ($F(2, 53) = 6.93, p = .001$). Both groups improved on their personal goals, although the memory strategy training group showed a larger improvement compared to the control group. Overall, 76% of the participants who completed the memory strategy training and 23% of the participants who completed the control memory training achieved a clinically significant improvement at follow-up (T2).

Table 1 Baseline characteristics.

	Memory strategy training			Control memory training			P-Value
	M	SD	n	M	SD	N	
Age	66.2	7.3	31	68.0	7.8	29	.34
Sex distribution							.02
Men %	68%		21	35%		10	
Women %	32%		10	66%		19	
Education (ISCED)	4.5	1.9	31	4.7	2.0	29	.66
Estimated IQ	106.1	17.6	29	109.2	17.3	29	.50
Outcome measures							
Memory Complaints Questionnaire	75.8	14.1	31	79.9	14.0	29	.26
Rating personal goals	4.1	0.74	28	4.2	1.1	28	.83
Strategy Use Inventory							
External strategies	21.9	4.6	31	22.4	3.1	29	.66
Internal strategies	26.7	8.0	31	29.1	4.9	29	.18
RBMT-3	90.9	12.5	31	92.3	18.3	29	.73
LLT							
Displacement score	28.6	23.2	31	27.2	21.3	29	.80
Learning index	0.51	0.31	31	0.60	0.28	29	.23
Recall score	-0.35	1.9	31	0.24	1.5	29	.18
RAVLT							
Total learning score	34.7	7.9	30	35.9	10.7	26	.65
Recall score	5.8	3.3	30	6.4	3.6	26	.53
Quality of life (RAND-36)	114.4	15.1	31	111.0	19.5	29	.46
Other neuropsychological tests							
Letter Fluency	34.9	10.0	30	31.7	10.1	29	.22
TMT A (sec)	45.0	18.0	29	48.6	18.8	25	.48
TMT B (sec)	97.5	29.0	27	95.7	32.9	23	.84
Digit Span	23.5	5.1	31	23.9	3.9	29	.73
Self-report measures							
GDS-15	2.8	2.5	31	2.7	2.9	27	.89
IADL	1.0	1.9	31	1.0	1.4	29	.94

Note. ISCED = International Standard Classification of Education; RBMT-3 = Rivermead Behavioural Memory Test – Third Edition; LLT = Location Learning Test; RAVLT = Rey Auditory Verbal Learning Test; TMT = Trail Making Test; RAND-36 = RAND 36-item Short Form Health Survey; GDS-15 = Geriatric Depression Scale; IADL = Instrumental Activities of Daily Living scale.

Table 2 Baseline, post-training and follow-up scores for primary and secondary outcome measures.

	Memory strategy training				Control memory training				Time T0-T1-T2				Treatment by Time Interaction			
	Mean ± SD		T1		T2		T0		T1		T2		F		P	
	T0	T1	T0	T1	T0	T1	T0	T1	T0	T1	T2	T0	F	P	F	η ² _p
Primary outcome^a																
Personal goal ratings	4.14 ± 0.7	6.38 ± 0.9	6.42 ± 1.0	4.20 ± 1.1	5.33 ± 1.1	5.24 ± 1.4	4.20 ± 1.1	5.33 ± 1.1	5.24 ± 1.4	64.70	<.0005	.71	6.93	.001	.21	
Memory complaints	75.77 ± 14.1	73.58 ± 12.7	73.94 ± 15.0	79.86 ± 14.0	80.10 ± 12.6	75.97 ± 14.0	79.86 ± 14.0	80.10 ± 12.6	75.97 ± 14.0	2.64	.040	.09	1.81	.087	.06	
Secondary outcome																
RBMT-3	90.9 ± 12.5	96.1 ± 11.6	93.0 ± 16.4	92.3 ± 18.3	92.6 ± 16.8	93.2 ± 20.3	92.3 ± 18.3	92.6 ± 16.8	93.2 ± 20.3	1.32	.275	.04	1.42	.251	.05	
LLT																
Displacement score	28.6 ± 23.2	19.5 ± 15.5	20.4 ± 18.8	27.1 ± 21.26	26.7 ± 24.1	20.2 ± 21.4	27.1 ± 21.26	26.7 ± 24.1	20.2 ± 21.4	5.26	.009	.08	1.67	.196	.03	
Learning index	0.51 ± 0.31	0.65 ± 0.27	0.73 ± 0.28	0.60 ± 0.28	0.53 ± 0.32	0.61 ± 0.34	0.60 ± 0.28	0.53 ± 0.32	0.61 ± 0.34	5.97	.003	.09	6.36	.002	.10	
Recall score	-0.35 ± 1.9	-0.47 ± 2.9	-1.2 ± 2.4	0.24 ± 1.5	-0.21 ± 2.4	-0.07 ± 2.0	0.24 ± 1.5	-0.21 ± 2.4	-0.07 ± 2.0	1.18	.308	.02	0.62	.521	.01	
RAVLT																
Total score	34.7 ± 7.9	42.1 ± 9.3	39.8 ± 10.1	35.9 ± 10.7	42.0 ± 10.7	39.9 ± 10.4	35.9 ± 10.7	42.0 ± 10.7	39.9 ± 10.4	17.46	<.001	.24	0.21	.808	.004	
Recall score	5.8 ± 3.2	8.3 ± 3.9	6.8 ± 3.8	6.4 ± 3.6	8.9 ± 3.6	8.3 ± 3.4	6.4 ± 3.6	8.9 ± 3.6	8.3 ± 3.4	25.91	<.001	.32	0.89	.401	.02	
Strategy Use Inventory																
External strategies	21.5 ± 3.2	21.7 ± 3.3	21.2 ± 4.0	22.4 ± 3.1	22.3 ± 3.7	22.4 ± 3.1	22.4 ± 3.1	22.3 ± 3.7	22.4 ± 3.1	0.27	.762	.005	0.45	.638	.008	
Internal strategies	25.5 ± 5.5	28.3 ± 5.2	27.8 ± 5.8	29.1 ± 4.9	29.9 ± 4.7	29.7 ± 5.3	29.1 ± 4.9	29.9 ± 4.7	29.7 ± 5.3	8.66	<.001	.13	2.78	.067	.05	
Quality of life (RAND-36)	115.77 ± 14.7	115.71 ± 16.8	114.16 ± 19.2	111.52 ± 20.0	113.07 ± 16.9	111.07 ± 19.4	111.52 ± 20.0	113.07 ± 16.9	111.07 ± 19.4	0.81	.451	.03	0.21	.808	.007	

Note. Values are presented as mean score (standard deviation). RBMT-3 = Rivermead Behavioural Memory Test – Third Edition; LLT = Location Learning Test; RAVLT = Rey Auditory Verbal Learning Test; T0 = baseline; T1 = post-training; T2 = 6 month follow-up.
^a one-tailed.

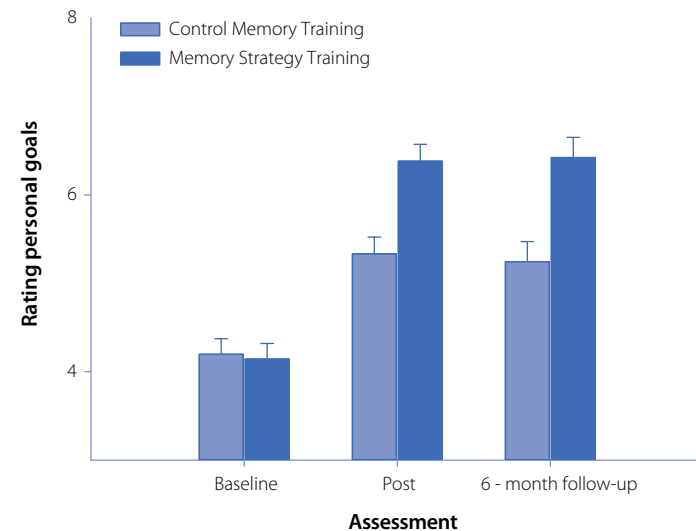


Figure 2 Average scores of the three personal goal ratings for the memory strategy training group and the control memory training group at baseline (T0), post-training (T1) and 6-month follow-up (T2). There was a significant increase in both groups ($p < .001$) and a significant interaction effect ($p = .001$). Standard error bars are shown.

Memory complaints

Results showed that after intervention, the subjective memory complaints decreased for both groups ($F(2, 57) = 2.64, p = .040$). No significant interaction effect was found ($F(2, 57) = 1.81, p = .087$). Moreover, only 4% of the participants in each group achieved a clinically significant improvement at follow-up (T2).

Training effects on secondary outcome measures

Results and statistical values are reported in Table 2. Both groups showed a significant improvement after training on two memory tests: the LLT and the RAVLT (both $p < .01$). Moreover, a significant interaction effect was found on the learning index score of the LLT ($p = .002$), in which the memory strategy training group showed a larger improvement than the control group. No significant effects were found for the RBMT-3. Regarding strategy use, a significant time effect ($p < .001$) and a marginal significant interaction effect ($p = .067$) were found, in which the memory strategy training group showed a larger increase in the use of internal strategies in daily life than the control group. No significant effects were found for external strategy use. No significant main or interaction effects were found for quality of life.

Predictors for treatment success

The increase in internal strategy use (difference score T1-T0) significantly predicted improvement in the memory strategy training group. At T1, an increase in internal strategy use was related to an increase in personal goal ratings ($\beta = .499, p = .012$) and a decrease in subjective memory complaints ($\beta = -.411, p = .043$). At T2, no significant predictors were found for the increase in personal goal ratings, whereas an increase in internal strategy use was related to a decrease in subjective memory complaints ($\beta = -.392, p = .045$). IQ estimation was a marginally significant predictor ($\beta = -.415, p = .052$) for the decrease in subjective memory complaints. Age, education level and external strategy use were not significantly associated with treatment improvement in the memory strategy training group. In the control memory training group, no significant predictors were found for improvement after treatment.

In addition, we examined whether age, education level and IQ estimation were predictors for the increase in internal strategy use (T1-T0), however no significant predictors were found.

Discussion

Older adults with subjective memory complaints report a larger improvement in memory functioning in daily life following memory strategy training compared to a control memory training in a randomized controlled trial. Although both interventions led to improvement in objective memory functioning, subjective memory complaints and in the personal memory goals, only the improvement on the personal memory goals was found to be significantly larger for the memory strategy training group. Six months after finishing the memory strategy training, 76% of the participants reported a clinically significant improvement on their personal memory goals, compared to 23% of the participants who completed the control memory training.

These results are in line with previous studies on the effect of memory training in older adults with subjective memory complaints or MCI (Metternich et al., 2010; Reijnders, van Heugten, & van Bortel, 2013). Previous studies have shown that psychoeducation, expectancy management and sharing experiences in a group are effective elements in memory interventions (Flynn & Storandt, 1990; Metternich et al., 2010; Reijnders, Geusgens, Ponds, & van Bortel, 2017; Valentijn et al., 2005), which could explain why both interventions in our study led to an improvement in memory test performance and in subjective memory functioning in daily life. The additional effect of memory strategy training in the present study seems to be related to the use of memory strategies, as we found that an increase in the use of internal strategies in daily life was positively correlated with the increase in personal goal ratings and to a decrease in subjective memory complaints after memory strategy training.

Both intervention groups showed an improvement on two memory tests: the LLT and RAVLT. Except for the learning index score of the LLT, memory strategy training did not have an additional effect on memory task performance. Previous studies on memory strategy training have found positive effects on objective cognitive functions (Cavallini, Dunlosky, Bottiroli, Hertzog, & Vecchi, 2010; Li et al., 2016; Talib, Yassuda, Diniz, Forlenza, & Gattaz, 2008). However, these studies mainly used laboratory tasks to train the memory strategies and did not examine generalization to daily life. Since older adults with subjective memory complaints still perform within the normal range on cognitive tasks yet experience their complaints in daily life situations, it could be argued that memory training should be aimed at improving memory functioning in daily life situations. Therefore, the present study included homework assignments to implement strategies in daily life, and did not actively stimulate the use of strategies during memory tests.

Following memory strategy training, adults used relatively more internal strategies in daily life, whereas the use of external strategies remained unchanged. A possible explanation for this is that older adults tend to use more memory strategies spontaneously to compensate for their experienced memory decline (Frankenmolen et al., 2017b). This is especially the case with external strategies, the use of which increases with age (Boazzaoui et al., 2010). This might indicate that there is little room left for improvement in external strategy use. However, previous studies suggest that although older adults with SMC use strategies, they often struggle to apply the learned strategies effectively (Frankenmolen et al., 2017b; Pike, Zeneli, Ong, Price, & Kinsella, 2015). Therefore, memory strategy training was not only aimed at increasing strategy use in daily life, but mainly focused on implementing and using the strategies more effectively in daily life situations. For example, most adults were familiar with making notes of important information, but during the training they learned to organize this written information more efficiently. Although the increase in personal goal ratings gives an indication of the effectiveness of the learned strategies, we did not examine this effect directly. Future studies on memory strategy use should include measures of effectiveness of the applied strategies. Furthermore, effective implementation of strategies has been related to a higher IQ level (Frankenmolen et al., 2017a; Frankenmolen, Fasotti, Kessels, & Oosterman, 2018), which may be a proxy for cognitive reserve (Stern, 2009; Galioto, Alosco, Spitznagel, Stanek, & Gunstad, 2013). Cognitive reserve is suggested to be protective against cognitive decline and to facilitate successful compensation (Stern, 2012). In the present study IQ was not related to an increase in strategy use or personal goal ratings, but IQ was a marginally significant predictor for the decrease in subjective memory complaints. Larger samples and broader IQ ranges of the participants should give more insight into the role of proxies of cognitive reserve in the effectiveness of strategy training.

Homework assignments of the memory strategy training were aimed at using strategies in the context of the three personal goals. It is known that older adults show limited transfer of the learned strategies to untrained situations (Cavallini et al., 2010). In this line, we found that adults improved meaningfully on their personal goals, while only showing

a small decrease on the subjective memory complaints questionnaire, which included mostly untrained situations. Although this training setup includes three memory goals that are functionally most important to the individual, future studies could examine whether additional sessions aimed at using strategies in other daily life situations increases transfer to untrained situations. An important limitation of this study is that the control memory training did not have homework assignments. Therefore, it is possible that the additional time and attention that was spent on the personal goals contributed to the improvement of personal goal ratings in the memory strategy training group. Furthermore, since one trainer performed all training sessions in order to prevent therapist effects (Firth, Barkham, Kellett, & Saxon, 2015), it was not possible to blind the trainer to treatment condition. As a result, a bias in personal preference of the trainer for the experimental condition cannot be ruled out.

In conclusion, this randomized and controlled study shows that memory strategy training improves memory functioning in daily life situations. The combination of psycho-education, expectancy management, sharing experiences in a group and training to use memory strategies in daily life situations is effective in older adults with subjective memory complaints and could be implemented in clinical practice.



Chapter 6

Summary and discussion

Summary and discussion

The main objective of this thesis was twofold. The first aim was to increase our understanding of memory strategy use in aging by examining its predictors, such as age, executive functioning and cognitive reserve. The second aim was to examine whether strategy training increases memory function in daily life in older adults with subjective memory complaints. In this final chapter, an overview of the main results and conclusions will be presented and discussed, followed by the studies' strengths and limitations. Finally, recommendations for clinical practice will be presented.

Main findings

In **Chapter 2**, spontaneous use of memory strategies was examined in a group of 83 adults with ages spanning the full adult lifespan (18-85 years), with a specific interest for the role of cognitive reserve, executive functioning and age. Memory strategy use was assessed using three measures: (1) self-reported strategy use in daily life; (2) self-reported and observed strategy use in a simulated daily-life situation; and (3) self-reported strategy use during a paired associate memory task. In order to observe strategy use, a novel paradigm was developed: the Strategy Observation Task (SOT). Overall, the results showed that cognitive reserve was the strongest predictor for strategy use. That is, adults with higher levels of cognitive reserve (indexed by educational level and IQ estimate) use more memory strategies in daily life and during the performance of memory tasks. Furthermore, cognitive reserve was related to the use of more complex strategies and to strategies that positively affected memory test performance. Although executive functioning was positively correlated with the use of some strategy measures and a higher age was negatively associated with some measures of strategy use, cognitive reserve overruled these effects in prediction analyses. Higher levels of cognitive reserve seem to enable individuals to use more complex and effective strategies to compensate for their aging-related memory decline.

Chapter 3 described a study examining the role of intelligence (as a proxy for cognitive reserve) on the effects of strategy instructions on memory performance in aging. A total of 142 adults (aged between 18 and 85 years) performed an associative memory task, either with or without receiving strategy instructions (sentence generation). Intelligence played an important role in the effect of strategy instructions, although its effect interacted with age. Whereas young adults with a lower IQ benefited from strategy instructions, those with a higher IQ did not. One explanation for this finding may be that young adults with a higher IQ already use effective strategies spontaneously and therefore cannot benefit from additional strategy instructions. In turn, older adults showed the opposite effect: following strategy instructions, older adults with a higher IQ showed a strong increase in memory performance (even approaching the performance level of younger adults), whereas older adults with a lower IQ did not, suggesting that the latter may have difficulties implementing the provided strategies.

In **Chapter 4**, memory strategy use was examined in a group of 38 older adults with and 38 older adults without subjective memory complaints (aged between 50 and 85 years). Older adults with subjective memory complaints used more strategies in daily life than those without. Moreover, memory complaints were positively correlated with strategy use, which indicates that strategy use may be a natural compensatory mechanism to deal with memory complaints. However, strategy use did not increase objective memory performance in these adults, suggesting that the use of strategies in older adults with subjective memory complaints might be less efficient than in older adults without complaints. No significant correlations were found between strategy use and educational level or IQ (proxies for cognitive reserve).

Chapter 5 describes a randomized-controlled trial (RCT) in 60 older adults (aged between 50 and 87 years) with subjective memory complaints on the effects of a memory strategy training, compared to a control memory training. The primary outcome measure was memory functioning in daily life, measured with personal memory goal ratings and a questionnaire for rating one's subjective memory complaints. Secondary outcome measures included objective memory performance, quality of life and strategy use in daily life. Both treatment arms of memory training led to improvement in subjective memory complaints and in personal memory goal ratings. However, the improvement on personal memory goals was significantly larger after memory strategy training than after the control treatment. Six months after finishing the memory strategy training, 76% of the participants still reported a clinically significant improvement on their personal memory goals, compared to only 23% of the participants who completed the control memory training. Regarding the secondary outcome measures, no beneficial effect was found of memory strategy training on objective memory performance or quality of life compared to the control memory training. For both types of memory training we found small improvements on two measures of episodic memory (i.e., word-list learning and object-location memory), but not on a test battery assessing everyday episodic memory functions (including prospective memory, memory for names or pictures and story recall). Furthermore, predictors for treatment success were examined. In the memory strategy training group, an increase in strategy use in daily life was the strongest predictor of an improvement in subjective memory functioning. Additionally, the level of estimated premorbid intelligence was marginally related to a decrease in subjective memory complaints. Age, educational level and premorbid IQ did not significantly predict the increase in strategy use after strategy training. Overall, these results indicate that older adults with subjective memory complaints benefit from memory strategy training, especially in their memory functioning in daily life.

General discussion

Memory strategies have shown their effectiveness in improving memory performance and in compensating for subjectively experienced memory decline (Metternich et al., 2010; Naveh-Benjamin, Brav, & Levy, 2007). The first aim of this thesis was to increase the knowledge about strategy use by examining its predictors. Previous studies have revealed that age and executive functioning are related to strategy use (Bouazzaoui et al., 2010; Dunlosky & Hertzog, 2001; Glisky et al., 2001; Naveh-Benjamin et al., 2007). However, most of these studies did not take into account measures of cognitive reserve (e.g., educational level, intelligence). We were among the first to report a direct relationship between cognitive reserve and memory strategy use (also, see Barulli et al., 2013). We showed that cognitive reserve was the strongest predictor for spontaneous strategy use across the adult-lifespan, both in daily life and during memory tasks (chapter 2). Secondly, cognitive reserve moderated the effect of strategy instructions in an associative memory task (chapter 3). These findings are consistent with the results of Nyberg et al. (2003), who suggest that cognitive reserve influences both the production efficiency (e.g., spontaneous strategy use) and the processing efficiency (e.g., efficient use of provided strategies) in older adults. Accordingly, older adults with higher levels of cognitive reserve use more effective strategies spontaneously to compensate for their experienced memory decline, but also benefit more from strategy training, because their higher level of cognitive reserve enables them to acquire and apply these strategies more efficiently.

In contrast, no significant relationship was found between strategy use and cognitive reserve in chapter 4. Whereas low correlations were found between educational level, IQ and strategy use in daily life in older adults without subjective memory complaints, no correlations were found in older adults with subjective memory complaints. A possible explanation could be related to the finding that older adults with subjective memory complaints already use more strategies spontaneously to compensate for their experienced memory decline. Seemingly, when older adults experience memory complaints they use more strategies in daily life, irrespectively of their level of cognitive reserve. Furthermore, in chapter 5, cognitive reserve neither predicted improvement in personal goals following strategy training, nor was it related to the increase in strategy use following strategy training. One potential explanation for this finding is that the memory strategy training in this thesis focused on implementing and using the strategies effectively on the three personal goals in daily life situations. By focusing on this implementation, the role of cognitive reserve may have been eliminated, as participants did not have to find ways to implement the strategies by themselves. Although the effect was small, cognitive reserve was found to be marginally related to a decrease in subjective memory complaints. This could imply that cognitive reserve plays a role in generalization of the learned strategies outside training situations. Possibly, older adults with higher levels of cognitive reserve are better able at using the strategies effectively in other, untrained memory situations as well, however we did not examine this directly.

An important difference between the first and the second part of this thesis lies in how strategy use was measured. Whereas chapter 2 and 3 included multiple measures of strategy use and measured the effectiveness on memory task performance, the strategy measures in chapter 5 were limited to the amount of self-reported strategies used in daily life. Chapter 2 demonstrates that cognitive reserve was mainly related to the use of more complex and deeper processing strategies, such as visual imagery and creating associations during task performance and that effectiveness of such strategies is enlarged in older adults with higher levels of cognitive reserve (chapter 3). Therefore, the role of cognitive reserve is more comprehensive than the mere amount of strategies used in daily life. This indicates that in order to examine effectiveness of our strategy training, measuring strategy use during a simulated daily life memory task such as the SOT is necessary. Future studies on memory strategy use or the effect of memory strategy training should therefore include a broader range of strategy use measures and examine the effectiveness of the applied strategies rather than solely the amount of strategies. Furthermore, we would recommend to examine the use and effectiveness of single strategies and to measure the complexity and depth-of-processing of these strategies. Regarding strategy use in daily life, it would be useful to examine adequate use of the strategies. That is, whether older adults use the strategies at the right moment and whether the used strategies fit the daily life memory task or situation. Finally, larger samples and broader IQ ranges of the participants should give more insight into the role of cognitive reserve in the effectiveness of strategy training.

In summary, cognitive reserve seems to play an important role in the production and processing of memory strategies. However, it is still unclear to what extent cognitive reserve influences the efficiency of the use of memory strategies in daily life and whether it moderates the effect of strategy training.

The second aim was to examine whether strategy training could improve memory functioning in daily life in older adults with subjective memory complaints. The results of an RCT in 60 older adults with subjective memory complaints showed that memory strategy training improves memory functioning in daily life situations. The proposed memory strategy training included a combination of psychoeducation, expectancy management, sharing of experiences in a group and training to use memory strategies in daily life situations. This study corroborates previous findings, but does so with a better design (e.g., an RCT with an active control group) and by including measures of memory functioning in daily life (in accordance with the recommendations outlined in Metternich et al., 2010). The findings are relevant for clinical practice, since this study is the first to show clinically relevant improvement in daily life memory functioning following memory strategy training. The memory strategy training in this thesis can be implemented to increase memory functioning in daily life in older adults with subjective memory complaints.

The training of memory strategies was aimed at teaching older adults to compensate for their experienced memory decline. The strategies of the training protocol are described in appendix 1. First, external strategies or memory aids are effective strategic resources to compensate for memory decline, since they almost entirely bypass a failing memory system and only require little cognitive effort (Lovelace & Twohig, 1990). However, it is not always possible or desirable to use memory aids, especially in social situations. Therefore, when someone's cognitive abilities are unimpaired, which is by definition the case in older adults with subjective memory complaints, the use of internal strategies is recommended in addition to the use of external strategies. The internal strategies used in this study are based on the theoretical models of aging-related memory decline. According to the Associative Deficit Hypothesis (Naveh-Benjamin, 2004; 2003; 2000) older adults have difficulties making associations between several units of information. The strategies *associating* and *structuring* enable older adults to create these associations more easily. Furthermore, the Interference Theory (Anderson et al., 2011) states that older adults are less efficient in suppressing competing memories and inhibiting interference, resulting in memory retrieval deficits. The strategies *attention*, *repetition* and *looking forward and backward* are aimed at preventing interference and at coping with it when it occurs. Finally, the Processing-Speed Theory (Salthouse, 1996) states that memory decline in older adults can in part be explained by a decrease in processing speed. The strategies *attention* and *time* are therefore aimed at creating the optimal environmental conditions to enable memory formation. All these strategies together facilitate memory formation and help older adults to compensate for various memory failures due to different underlying mechanisms.

One of the major challenges in strategy training is generalization of the trained strategies. It is known that older adults show limited transfer of the acquired strategies to untrained situations (Cavallini et al., 2010). Thus, it is important to actually train the use of memory strategies in these daily life situations, rather than during memory tasks in an artificial controlled setting. In our RCT we therefore included exercises that mimic daily life situations, such as practicing with remembering conversations and remembering names. Additionally, homework assignments focused on practicing the strategies at home in situations related to their personal memory goals. This training setup included three memory goals that were functionally most relevant to the participants. Unfortunately, there seemed to be limited transfer to untrained situations, since there was no beneficial effect of strategy training on the subjective memory complaints and only a marginal effect in the increase of strategy use in daily life following strategy training. Future studies should examine whether additional sessions or additional exercises aimed at using strategies in other daily life situations increases transfer to untrained situations and thereby increases the effect of memory strategy training on subjective memory complaints. For example, generalization could be improved by stimulating participants to speculate on how strategies could be used in other daily life situations and by practicing these situations within the sessions.

Strengths and limitations

Several strengths and limitations of the studies performed for this thesis are discussed here. First, with respect to the RCT, important strengths are that the memory strategy training was aimed at improving daily life memory functioning and that we used subjective measures as primary outcome measures, whereas previous studies focused on improving memory test performance and mainly used objective memory tests as primary outcome measures (Metternich et al., 2010). We used a tailored approach in which individually selected memory goals were chosen by our older participants, thereby increasing the feasibility of the training for each participant. Furthermore, our trial had a better methodological quality than previous studies, as it included an active control group and a follow-up assessment after six months.

Another strength of our approach was that we used multiple measures of strategy use (chapter 2): self-reported strategy use in daily life, observed strategy use and self-reported strategy use during a memory task. Previous studies generally examined strategy use *either* in daily life *or* during task performance, and additionally did not distinguish between self-reported strategies and those that were truly employed during encoding. This latter distinction is crucial, as Saczynski, Rebok, Whitfield and Plude (2007) have shown that adults are often unaware of the strategies that they have used, suggesting that they may underestimate their true strategy use in self-report questionnaires. We made a first attempt at developing a task (the Strategy Observation Task; SOT), including the observation of strategy use as well as a self-report questionnaire. Although further research is needed to further validate the SOT, it seems to be a feasible measure to examine strategy use in a more objective way. For logistic reasons, however, we could not use multiple measures of strategy use in our RCT. Although the memory strategy training was aimed at improving memory strategies in daily life, it would have been preferable to include more objective measures of strategy use and to examine the use of memory strategies during memory tasks.

Several other limitations should be noted. An important limitation is that we used a limited amount of measures to estimate cognitive reserve. The concept of cognitive reserve is often described as a capacity that is acquired through cognitively demanding and stimulating experiences, such as education (Reed et al., 2010). Other studies suggest that degree of literacy or verbal IQ might be a better measure for cognitive reserve than the number of years of education (Alexander et al., 1997; Manly, Schupf, Tang, & Stern, 2005). Therefore, some studies, including the studies in this thesis, used a combination of education and (estimated) IQ as proxy for cognitive reserve (Barulli et al., 2013; Giogkaraki et al., 2013; Sakamoto et al., 2013). Although educational level and IQ are widely used, additional information on occupational attainment and engagement in cognitively stimulating leisure activities can provide a more accurate estimation of cognitive reserve (Opdebeeck, Martyr, & Clare, 2016; Stern, 2009), since these measures include lifetime experiences. In future studies we recommend to use a combination of these measures to

define cognitive reserve, for instance the Cognitive Reserve Index questionnaire, which assesses levels of education, occupation and leisure activities (Nucci, Mapelli, & Mondini, 2012).

Regarding our RCT, we also did not include untrained daily-life memory tasks. Therefore, we were not able to measure transfer of the trained strategies to untrained tasks. Moreover, although we made a first attempt to examine predictors of treatment success following memory strategy training, these analyses were exploratory in nature and were not based on a-priori hypotheses. Also, future studies with larger groups of participants should investigate which participants benefit most from memory strategy training at an individual level and specifically, whether cognitive reserve increases the beneficial effects of memory strategy training.

Clinical implications

Based on the studies in this thesis several relevant recommendations for clinical practice can be made. We have shown that memory strategy training improved memory functioning in daily life in older adults with subjective memory complaints. In addition, we also performed a qualitative evaluation, in which we asked participants how they experienced the training. Almost all participants were highly positive about the training and thought the training was useful. One of the most reported positive aspects of the training was that it was tailor-made and focused on the training of personal memory goals. The training did not aim to improve memory function in general, as memory functioning in these older adults is still in the normal range. Although there was a large clinically significant improvement on the three personal memory goals, generalization of the trained strategies seemed to be limited, since there was only a small improvement on subjective memory complaints in general. Therefore, it is important to select treatment goals that are functionally most relevant for each participant. Training these specific daily life memory tasks could improve functional independence and participation in older adults.

One of the major issues related to our sample is that older adults with subjective memory complaints do not fulfill the criteria for an illness or clinical diagnosis, and therefore do not receive clinical care in the Netherlands. Still, subjective memory complaints are associated with a decline in everyday functioning and a lower quality of life (Balash et al., 2013; Jessen et al., 2014; Montejo et al., 2011). Furthermore, since these older adults have an increased risk for future cognitive decline and dementia (Luck et al., 2015; Mendonca et al., 2016; Mitchell et al., 2014), early intervention would enable them to cope with their memory complaints for longer periods of time, thereby compensating for possible future cognitive decline. Hence, we would recommend the implementation of this memory strategy training and offer this as a treatment for older adults with subjective memory complaints. One option is to implement this training in primary care, where mental health assistants could give the training in small groups. Another option is to make this training available in the community at low costs, facilitated by the community council.

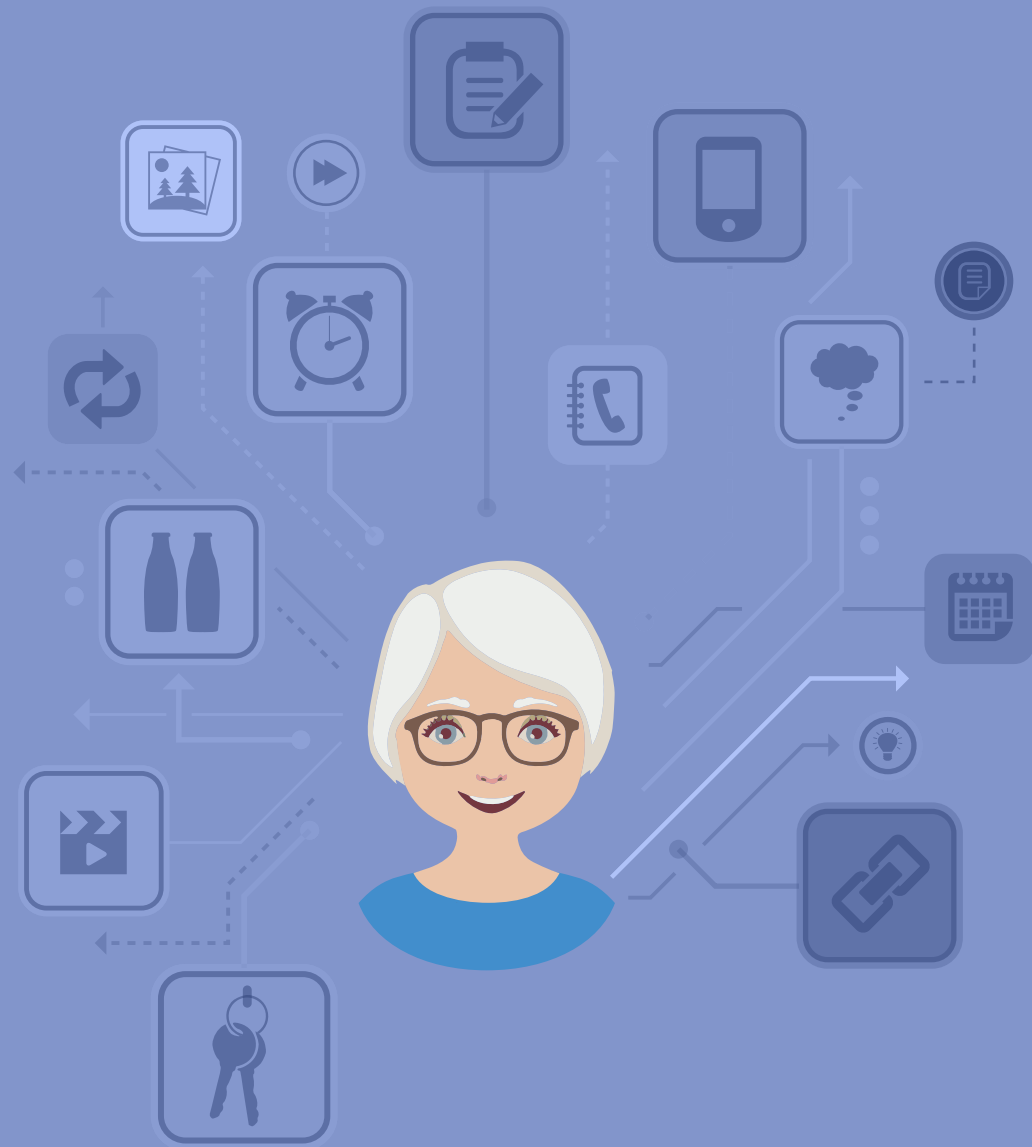
Future research could also examine the possibilities of providing this intervention as an e-health service. E-health would reach much more older adults at lower costs than a traditional group training. Despite the fact that sharing experiences in a group is an important element in memory training (Flynn & Storandt, 1990), others have argued that online interventions can be as effective as traditional interventions for healthy older adults (Rebok, Carlson, & Langbaum, 2007). Furthermore, Reijnders et al. (2017) have shown that a psychoeducational e-health intervention on cognitive functioning improved the perceived locus of control over memory functioning in healthy adults. Whether a more extensive approach, such as the memory strategy training in this thesis, would also be applicable as e-health intervention should be examined in future research.

Finally, it would be interesting to include measures of cognitive reserve, such as educational level or IQ, in clinical practice. As this thesis has demonstrated, cognitive reserve plays an important role in the production and processing of memory strategies. We have shown that older adults with higher levels of cognitive reserve benefit more from the use of strategies than older adults with lower levels of cognitive reserve. Although further research is needed, measures of cognitive reserve could be helpful in selecting individuals in which compensatory strategy training would be beneficial.

Conclusion

The main objective of this thesis was to improve the knowledge about memory strategy use and strategy training in aging. The studies in this thesis showed that cognitive reserve plays an important role in the production and processing of memory strategies in aging. A higher cognitive reserve is related to the use of more strategies, but also to the use of more complex and more effective strategies. Moreover, older adults with higher levels of cognitive reserve benefit more from strategy instructions, indicating that they are better at processing and implementing the learned strategies. Furthermore, this thesis has shown that older adults with subjective memory complaints benefit from memory strategy training, especially in their daily life functioning. The investigated strategy training contributes to the improvement of memory interventions in older adults and can be implemented in clinical practice. Memory strategies enable older adults to compensate for their experienced memory decline. So, *don't forget to grow old* and use memory strategies to help you.

Session	Summary	Content
1	Psychoeducation, cognitive-restructuring	Education about the memory system, normal aging-related memory decline and the differences with types of dementia, the role of stress and healthy lifestyle, and how to influence aging-related memory decline with the use of strategies.
2	Formulating memory goals	Formulate three personal goals related to memory problems in daily life.
	External strategies	Putting objects in a conspicuous and fixed place Taking notes (preferably in a notebook) and making shopping lists Use a diary to plan appointments Set an alarm or timer Use a calendar for birthdays or family appointments Use the memory of someone else for important meetings
3	Internal strategies part 1	Attention: deliberately concentrate on information that has to be remembered and try to inhibit or prevent distraction. Time: take some time to remember information and divide cognitive tasks throughout the day. Try to prevent multi-tasking. Repetition: actively rehearse information (out loud), preferably on several moments in different situations.
4	Internal strategies part 2	Associating: make associations between new information and old memories through the use of mnemonics or visual imagery. Structuring: categorize information, such as groceries and organize objects. Looking forward and backward: use visual imagery to encode and plan future events or to remember previous information, such as lost objects.
5	Rehearsal Module "Remembering texts"	Rehearsal of all external and internal strategies Remember texts by using some external strategies (notes, marker) and all internal strategies (attention, time, looking forward, associating, structuring and repetition).
6	Module "Remembering conversations" Module "Dealing with distraction"	Remember conversations by using several internal strategies (looking forward, attention, time, repetition, structuring, associating and looking backward). Deal with distraction by using both internal (attention, time, looking forward and backward) and external strategies (objects or notes).
7	Module "Remembering names and faces" Evaluation	Remember names and faces by using several internal strategies (attention, time, repetition and associating).



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Nederlandse samenvatting

Dankwoord

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Nederlandse samenvatting

Geheugenproblemen komen vaak voor bij normale veroudering. Zo toonde de Maastricht Aging Study aan dat vergeetachtigheid bij ongeveer 41% van de mensen tussen 55 en 65 jaar voorkomt, en tussen de 70 en 85 jaar zelfs bij 52% (Ponds, Commissaris & Jolles, 1997). Ondanks het feit dat een achteruitgang in het geheugen normaal is bij veroudering, geeft 23% van de ouderen aan dat de geheugenklachten tot problemen leiden in het dagelijks leven. Het ervaren van geheugenklachten heeft ook een negatief effect op de kwaliteit van leven (Mol et al., 2007). Dit toont het belang aan van onderzoek naar interventies om geheugenklachten te verminderen.

Binnen de neuropsychologie wordt onderscheid gemaakt tussen het werkgeheugen en het langetermijngeheugen. Het werkgeheugen gebruiken we wanneer we tijdelijk informatie actief houden om er iets mee te doen (bijvoorbeeld hoofdrekenen of het kortdurend onthouden van een telefoonnummer). In het werkgeheugen kunnen we gedurende enkele seconden informatie vasthouden, waarbij de capaciteit van het werkgeheugen beperkt is tot 5-7 eenheden van informatie. Het werkgeheugen speelt een belangrijke rol bij het opslaan van nieuwe informatie. Het langetermijngeheugen is het systeem waar herinneringen in worden opgeslagen, variërend van minuten tot decennia, met een onbeperkte capaciteit. Het episodisch geheugen is een belangrijk onderdeel van het langetermijngeheugen en omvat herinneringen van specifieke, persoonlijke gebeurtenissen (bijv. een vakantie of wat je in het weekend hebt gedaan). In dit proefschrift richt ik me met name op het episodisch geheugen: het opnemen, opslaan en ophalen van persoonlijke informatie binnen een context (tijd en plaats).

Wanneer we ouder worden gaan verschillende cognitieve functies achteruit als gevolg van veranderingen in de hersenen. Veroudering gaat met name samen met een achteruitgang in het episodisch geheugen (Nilsson, 2003), waarbij ouderen moeite hebben met het gelijktijdig opslaan van informatie in de juiste context (bijvoorbeeld een naam onthouden samen met een gezicht en de bijbehorende sociale context waarin je iemand hebt ontmoet). Een deel van de ouderen laat ook objectieve geheugenstoornissen zien, oftewel een achteruitgang die groter is dan wat bij normale veroudering verwacht kan worden. Dit kan duiden op een neurodegeneratieve aandoening, zoals de ziekte van Alzheimer. Echter, het grootste gedeelte van de ouderen ervaart *subjectieve* geheugenklachten, waarbij iemand vergeleken met leeftijdsgenoten nog volgens de norm presteert op geheugentesten (en er dus geen sprake is van een geheugenstoornis). Er zijn wel aanwijzingen dat ouderen met subjectieve geheugenklachten een anderhalf tot drie keer grotere kans hebben op het ontwikkelen van dementie (Luck et al., 2015). Ondanks de grotere kans op verdere cognitieve achteruitgang, zullen de meeste mensen met subjectieve geheugenklachten echter geen dementie ontwikkelen. Andere factoren, zoals persoonlijkheid, een hoog streefniveau en een lage zelfwaardering, zijn ook gerelateerd aan het al dan niet hebben van subjectieve geheugenklachten (Jungwirth et al., 2004). Omdat

ouderen met subjectieve geheugenklachten een grotere kans hebben op verdere cognitieve achteruitgang, meer stress en depressieve klachten ervaren en een lagere kwaliteit van leven rapporteren, is het van belang om vroegtijdig interventies in te zetten met als doel de klachten in het dagelijks leven te verminderen.

Geheugentrainingen kunnen grofweg ingedeeld worden in twee categorieën. De eerste is restoratieve training of *brain training*. Deze categorie is erop gericht om het geheugen te verbeteren door middel van oefenen van geheugentaken. Onderzoek laat zien dat mensen vooruitgaan op geheugentesten, maar dat er nauwelijks generalisatie optreedt naar het dagelijks leven (Owen et al., 2010). Anders gezegd: de verbetering in prestatie leidt niet tot een merkbare vermindering van de geheugenproblemen in het dagelijks leven. De tweede categorie is compensatoire training of strategietraining, waarbij mensen leren om te compenseren voor een verminderd geheugen met behulp van geheugenstrategieën. Deze strategieën kunnen ook in het dagelijks leven worden ingezet en zijn daarom relevanter voor de geheugenproblemen van alledag. In dit proefschrift richt ik me daarom verder op de training van geheugenstrategieën bij ouderen met subjectieve geheugenklachten. Er wordt hierbinnen onderscheid gemaakt tussen externe strategieën (hulpmiddelen, zoals agenda of notitieblok) en interne strategieën (mentale strategieën, zoals visualiseren of associaties maken). Er zijn aanwijzingen dat het gebruik van geheugenstrategieën verandert naar mate mensen ouder worden. Ook lijkt cognitieve reserve hier een rol in te spelen. Cognitieve reserve speelt een rol bij het al dan niet kunnen compenseren voor cognitieve achteruitgang en wordt voor een belangrijk deel bepaald door iemands opleidingsniveau en intelligentie (Stern, 2009). Of cognitieve reserve samenhangt met effectief strategiegebruik is tot op heden echter niet onderzocht.

In dit proefschrift heb ik onderzoek gedaan naar het gebruik van geheugenstrategieën bij veroudering en naar het effect van een geheugenstrategietraining bij ouderen met subjectieve geheugenklachten.

In **hoofdstuk 2** werd het spontaan gebruik van geheugenstrategieën onderzocht bij 83 volwassenen tussen de 18 en 85 jaar. Strategiegebruik werd met drie verschillende maten onderzocht: 1) een vragenlijst naar strategiegebruik in het dagelijks leven; 2) strategiegebruik werd geobserveerd en nagevraagd tijdens een situatie die leek op een taak uit het dagelijks leven; en 3) strategiegebruik werd nagevraagd na het uitvoeren van een associatieve geheugentest (woordparen). Om strategiegebruik te kunnen observeren is een nieuwe taak ontwikkeld: de *Strategy Observation Task* (SOT). Resultaten lieten zien dat cognitieve reserve het sterkst strategiegebruik kon voorspellen. Volwassenen met een hogere cognitieve reserve (dat wil zeggen een hoger IQ en opleidingsniveau) bleken meer strategieën te gebruiken in het dagelijks leven en tijdens geheugentaken. Ook was cognitieve reserve gerelateerd aan het gebruik van complexere en effectievere geheugen-

strategieën. Cognitieve reserve lijkt dus een rol te spelen bij effectieve compensatie voor leeftijd gerelateerde achteruitgang van het geheugen.

Hoofdstuk 3 beschrijft een studie naar het effect van strategie-instructies op geheugenprestaties, waarbij specifiek naar de rol van intelligentie werd gekeken (als maat voor cognitieve reserve). Een associatieve geheugentest (woordparen) werd afgenomen bij 142 volwassenen tussen de 18 en 85 jaar, waarbij de helft van de deelnemers specifieke instructies kreeg om een strategie te gebruiken (het maken van een zin met beide woorden) en de andere helft geen specifieke instructies kreeg. Het effect van deze strategie-instructies werd beïnvloed door intelligentie en leeftijd. Jongeren met een lager IQ hadden baat bij deze instructies, terwijl jongeren met een hoger IQ na strategie instructies niet beter presteerden. Een verklaring hiervoor kan zijn dat jongeren met een hoger IQ spontaan al effectieve strategieën gebruiken en daarom niet profiteren van extra instructies. Bij ouderen werd een tegenovergesteld effect gevonden. Ouderen met een hoger IQ profiteerden sterk van strategie-instructies, waarbij zij zelfs op het zelfde niveau presteerden als de jongeren, terwijl ouderen met een lager IQ vrijwel niet profiteerden. De hypothese hierbij is dat ouderen met een lager IQ moeite hebben om de strategie te implementeren.

In **hoofdstuk 4** werd het spontaan gebruik van strategieën onderzocht bij 38 ouderen met en 38 ouderen zonder subjectieve geheugenklachten (leeftijd tussen de 50 en 85 jaar). Ouderen met subjectieve geheugenklachten gaven aan meer strategieën te gebruiken in hun dagelijks leven dan ouderen zonder deze klachten. Er werd bovendien een positieve correlatie aangetoond tussen geheugenklachten en strategiegebruik. Vermoedelijk is strategiegebruik een spontaan mechanisme om te kunnen compenseren voor alledaagse geheugenklachten. Strategiegebruik leidde echter niet tot een verbeterde geheugenprestatie bij ouderen met subjectieve geheugenklachten. Mogelijk zijn de strategieën van deze ouderen minder efficiënt dan die van ouderen zonder geheugenklachten. Er werd geen relatie gevonden tussen strategiegebruik en het IQ of opleidingsniveau (als maat voor cognitieve reserve).

Hoofdstuk 5 beschrijft de studie naar het effect van een geheugenstrategietraining bij 60 ouderen met subjectieve geheugenklachten. In een gerandomiseerde gecontroleerde studie (*randomized controlled trial* of RCT) werd de geheugenstrategietraining vergeleken met een controle geheugentraining, welke bestond uit een vorm van *brain training*. In beide trainingen werd daarnaast ook psycho-educatie gegeven en beide trainingen vonden in kleine groepjes plaats. De belangrijkste, primaire uitkomstmaat was het geheugenfunctioneren in het dagelijks leven. Daarnaast keken we naar het effect op verschillende geheugentesten, de kwaliteit van leven en het strategiegebruik.

Beide trainingen resulteerden in een vermindering van subjectieve geheugenklachten en in een vooruitgang op persoonlijke doelen met betrekking tot het geheugenfunctioneren in het dagelijks leven. De deelnemers die de geheugenstrategietraining kregen lieten een sterkere vooruitgang op persoonlijke doelen zien dan de deelnemers die de controle-

training kregen. Tot zes maanden na de geheugenstrategietraining liet 76% van de deelnemers een klinisch betekenisvolle vooruitgang zien, vergeleken met 23% van de deelnemers na de controletraining. De geheugenstrategietraining leidde niet tot een sterkere vooruitgang met betrekking tot de geheugentesten. Beide trainingen resulteerden in een kleine vooruitgang op twee van de drie geheugentesten.

Daarnaast werd onderzocht welke variabelen de vooruitgang na de training konden voorspellen. Deelnemers die meer strategieën in het dagelijks leven gebruikten na de geheugenstrategietraining lieten ook een sterkere vooruitgang zien op hun persoonlijke doelen en hadden een grotere afname van hun subjectieve geheugenklachten. Geconcludeerd werd dat ouderen met subjectieve geheugenklachten profiteren van geheugenstrategietraining, met name in het functioneren in het dagelijks leven.

Tot slot wordt in de algemene discussie (**hoofdstuk 6**) een beschouwing van de bevindingen van dit proefschrift gegeven. Er wordt onder andere stilgestaan bij de mogelijke rol van cognitieve reserve in relatie tot het gebruik van geheugenstrategieën. Op basis van de onderzoeken in dit proefschrift en de bestaande literatuur kan worden geconcludeerd dat cognitieve reserve een belangrijke rol speelt in het spontaan produceren en het implementeren van geheugenstrategieën. Het is echter nog onduidelijk of cognitieve reserve ook het effect van strategietraining beïnvloedt. Ten aanzien van het effect van de geheugenstrategietraining kan geconcludeerd worden dat deze training effectief is, met name in het functioneren in het dagelijks leven. Een van de grootste uitdagingen bij strategietraining ligt in de mate van generalisatie van de getrainde strategieën, dat wil zeggen het toepassen van strategieën in andere, niet-getrainde situaties. Er wordt gespeculeerd over manieren om generalisatie te verbeteren in verder onderzoek. Daarnaast worden de sterkte en zwakte punten van de onderzoeken besproken, worden er suggesties gedaan voor vervolgonderzoek en worden de implicaties voor de klinische praktijk beschreven.

Al met al kan geconcludeerd worden dat ouderen met subjectieve geheugenklachten profiteren van geheugenstrategietraining in het dagelijks leven. Geheugenstrategieën helpen ouderen om te compenseren voor de ervaren achteruitgang van het geheugen. De onderzochte strategietraining draagt bij aan de ontwikkeling en verbetering van geheugentrainingen en kan worden geïmplementeerd in de klinische praktijk.

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Curriculum Vitae

Nikita L. Frankenmolen is op 12 oktober 1989 geboren in Ede. Na afronding van het vwo aan het Pallas Athene College in Ede in 2008 is zij gestart met de studie Psychologie aan de Radboud Universiteit in Nijmegen. Tijdens deze studie volgde zij het Honours-programma Psychologie, waarvoor zij in het eerste jaar onderzoek deed op de afdeling Biologische Psychologie van de Radboud Universiteit naar een ratmodel van absence-epilepsie en in het tweede jaar stage liep bij Kempenhaeghe, het Academisch Centrum voor Epileptologie, waar zij fMRI-onderzoek deed bij patiënten met temporaalkwab-epilepsie. Daarnaast is zij tijdens haar studie werkzaam geweest als onderwijsassistent bij de sectie Neuro- en Revalidatiepsychologie van de Radboud Universiteit. In 2013 behaalde zij *cum laude* haar masterdiploma Gezondheidszorgpsychologie. Aansluitend is zij parttime gaan werken als onderzoeksassistent binnen het Donders Instituut van de Radboud Universiteit, waar zij met behulp van een subsidie van FNO gedurende drie jaar onderzoek deed naar strategiegebruik en het effect van een geheugenstrategietraining bij ouderen. In de loop van het traject is het onderzoek uitgegroeid tot promotieonderzoek, waardoor zij als buitenpromovendus verbonden bleef aan het Donders Instituut. Naast het promotie-traject heeft zij tussen 2013 en 2016 op verschillende afdelingen van Klimmendaal Revalidatiespecialisten gewerkt als psycholoog. Sinds september 2016 is zij bij Klimmendaal in opleiding tot gezondheidszorgpsycholoog, die zij in de zomer van 2018 afrondt. Vanaf september 2018 zal zij als gezondheidszorgpsycholoog verbonden blijven aan Klimmendaal en zich richten op de cognitieve revalidatiebehandeling van patiënten met Niet Angeboren Hersenletsel (NAH). In de toekomst hoopt zij onderzoek en patiëntenzorg te blijven combineren.

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